WAWASEE AREA
W.A.C.F.
CONSERVANCY FOUNDATION

LAKE WAWASEE ENGINEERING FEASIBILITY STUDY

HARZA
ENGINEERING COMPANY

LAKE WAWASEE ENGINEERING FEASIBILITY STUDY

Prepared for

Wawasee Area Conservancy Foundation

Prepared By

HARZA
Engineering Company

Under the Sponsorship of
Indiana Department of Natural Resources
Lake and River Enhancement Program

May 2001

EXECUTIVE SUMMARY

Lake Wawasee is located in the northeast section of Kosciusko County in northcentral Indiana, and is generally bordered by Route 13 to the west, the Noble County line to the east, and the Elkhart County line to the north. A popular site for recreation and fishing, Lake Wawasee is Indiana's largest natural lake. The lake's surface area is 3,400 acres, with a maximum depth of 77 feet and a mean depth of 22 feet. Runoff from the 24,450-acre watershed flows into Lake Wawasee through Turkey Creek, Papakeechie Lake, Bonar Lake, Dillon Creek/Enchanted Hills, and several smaller drainages. Lake Wawasee's watershed drains to the northwest to the St. Joseph River, a tributary of Lake Michigan.

The objective of this engineering feasibility study is to evaluate the technical, environmental, and social feasibility of Wawasee Area Conservancy Foundation (WACF)-identified projects that enhance water quality and the environmental value of Lake Wawasee. Pollution control projects were assessed at four locations around the lake: Enchanted Hills, South Shore, Bayshore, and Leeland Addition (Figure 1). For each potential project, we produced preliminary design and documents, hydraulic and hydrologic analysis, lake response, permit requirements, easements and land availability, unusual physical and social costs, bioassessment data, probable cost of construction, and recommendations. In addition, special assessments of refacing of seawall with glacial stone and an environmental function of Mud Lake are also included.

Restoration of the Original Flow Channel From Enchanted Hills to Johnson Bay Wetland

Before the Enchanted Hills subdivision was developed, Dillon Creek flowed into Johnson Bay through the wetland system to the north and east of the bay. The water quality benefits of rerouting Dillon Creek through the Johnson Bay wetland include reduced sediment and nutrient load entering Lake Wawasee. In order to restore flow of Dillon Creek to Johnson Bay, the water level in the Enchanted Hills channels must be raised. Alternatives to raise the water level, while maintaining navigation include:

- A lock and dam at the outlet of the channels to Lake Wawasee
- A flood gate at the outlet to Lake Wawasee

We recommend the lock and dam, because it restores all flow to Johnson Bay, flood forecasting is not required, and it maintains navigation during high water. The project is estimated to cost $202,000, and would provide a natural filtering mechanism through the wetland. Velocities in the Enchanted Hills channels during storm flows will also be reduced by about one-third due to the higher elevation of the water level. This will slightly reduce erosion of the channel banks. There are potential negative impacts to the Johnson Bay Wetland, and these are identified in our report.

Grade and Bank Stabilization in the Enchanted Hills Subwatershed

The Enchanted Hills subdivision consists of homes (some atop steeply graded hills) abutting man-made channels, some of which are eroding and contributing sediment to Lake Wawasee. Harza performed a lot-by-lot assessment of the subdivision to identify areas in need of bank and grade stabilization. Shoreline was categorized as followed:

- “Severe” erosion totaled approximately 5,310 lineal feet
- “Moderate” erosion totaled approximately 2,145 lineal feet
- “Slight” erosion totaled approximately 2,670 lineal feet
- “Potential” erosion totaled approximately 4,269 lineal feet

We recommend that the areas of severe erosion be the initial focus of the grade and bank stabilization improvements, and fiber rolls, herbaceous vegetation, sheetpiling, and boulders and stone are identified as the best treatments. The estimated cost of treating the 5,310 lineal feet of severely eroding banks is $2,673,000. The expected benefit is a 64% annual reduction in the amount of sediment from the channel banks.

Sediment Trap/Constructed Wetland on Dillon Creek

This project would provide for detention and water quality treatment upstream of Enchanted Hills on Dillon Creek. Three alternative sites on Dillon Creek, DC1, DC2, and DC3, were evaluated for biological integrity, water quality, and construction feasibility. All three sites showed comparable biological characteristics, and are characterized as forested wetlands. As the biological integrity of each site is similar, we recommend investigating the feasibility of a constructed wetland at DC2, due to the superior physical aspects of the site. An enhanced wetland created by a sheetpile dam, and a cable dam are the two options we examined for this site.

We recommend constructing an enhanced wetland (sheetpile dam) at site DC2, due to its estimated efficiency of 54%, lower maintenance requirements than the cable dam, and its proven effectiveness as a treatment technology. The estimated cost for this project is $93,000.

Erosion Control on Development Sites and Sediment Trap and/or Stormwater Retention in the Leeland Addition (Martin Ditch)

Martin Ditch collects stormwater runoff from surrounding agricultural areas, and flows to Lake Wawasee. The fields near Martin Ditch are classed as highly erodible lands. Erosion of the streambed between County Road 800 E and the Leeland Addition Road is also likely a source of sediment to the channels (NRCS, 1999). We investigated source control on surrounding farm and residential properties, a series of riprap check dams on Martin Ditch, and a sediment trap in the channel north of South Drive.

We recommend installing the check dams on Martin Ditch, due to the cost and estimated velocity reduction of up to 68%. We also recommend developing and implementing an on-farm erosion control plan for the Leeland Addition watershed. The check dams are estimated to cost $29,000 and the erosion control plan is estimated to cost $2,000.

Erosion Control on Development Sites and Sediment Trap and/or Stormwater Retention in the South Shore Subwatershed

The South Shore Area consists of a ditch draining the South Shore Golf Course and Route 13 to Lake Wawasee. While we have no water quality data, it is likely that fertilizers and other chemicals used to treat the golf course are entering the South Shore Ditch via stormwater runoff. Bank erosion has been observed in the streambed to the east of Route 13, and it is likely a minor source of sediment to the lake. The clubhouse and parking lot of the golf course drains directly to Lake Wawasee via an underdrain, and it is possible that nutrients and sediment are entering the lake from this drainage. We investigated a sediment trap on South Shore Ditch, a nutrient management plan for the golf course, and a bioretention facility for the golf course parking lot.

We recommend preparing a nutrient management plan for the golf course, and installing a bioretention facility east of the golf course parking lot. These two choices will address both the area of the golf course that drains north to South Shore Ditch, and the area that drains east to the lake via an underdrain. The nutrient management plan is estimated to cost $2,000. The bioretention facility is estimated to cost $179,000 and will remove 90% of the total suspended solids, and 70-80% of the nutrients in the runoff.

Reconstructed Wetland in the Bayshore Swamp

The Bayshore Area consists of a residential area developed around dredged boat channels to the lake. The Bayshore channel is fed by a ditch that collects agricultural runoff also from fields to the south of Hatchery Road. There is an existing wetland system to the south of Hatchery Road that spans CR 850E, with a culvert under the road. We investigated impounding the wetland west of CR 850E, and in-channel sediment trap at Bayshore. We recommend the sediment trap in the Bayshore channel, due to its estimated trapping efficiency of 45%. The estimated cost of the project is $69,000.

The following tables present the budget and schedule for the implementation projects. To develop this cost, we used estimates from previously published reports, and adjusted by an inflation and safety factor of 10%. For materials costs less than $100,000, engineering fees were calculated at 15% of the materials cost. For materials costs above $100,000 engineering fees were calculated at 10% of the materials cost. Services during construction were estimated at 10% of the materials cost. A 25% contingency was applied to the subtotal of materials, engineering, and services during construction. This estimate is based on 2001 dollars. The stilling basin will be designed to hold 2-3 years worth of sediment, after which time maintenance costs will be incurred for sediment removal. Annual inspection of the structure is also recommended.

BUDGET FOR DESIGN AND IMPLEMENTATION PROJECTS

Treatment Type	Section	Construction	Services	Engineering	Contingency	Total
Restore Dillon Creek Flow to Johnson Bay Via Lock and Dam	4.1	$133,000	$14,000	$14,000	$41,000	$202,000
Enchanted Hills Grade and Bank Stabilization	4.2	$1,943,000	-	$195,000	$535,000	$2,673,000
Enhanced Wetland on Dillon Creek at DC2	4.3	$59,000	$6,000	$9,000	$19,000	$93,000
Erosion Control Plan for Leeland Addition Watershed	4.4	-	-	$1,800	$200	$2,000
Five Check Dams on Martin Ditch	4.4	$18,000	$2,000	$3,000	$6,000	$29,000
Nutrient Management Plan for South Shore Golf Course	4.5	-	-	$1,800	$200	$2,000
Bioretention for South Shore Country Club Parking Lot	4.5	$119,000	$12,000	$12,000	$36,000	$179,000
Sediment Trap in Bayshore Channel	4.6	$43,000	$5,000	$7,000	$14,000	$69,000
Total		**$2,315,000**	**$39,000**	**$243,600**	**$651,400**	**$3,249,000**

We recognize that funds may not be available for immediate design and implementation of all of these recommended projects. Therefore, we recommend that the following five projects be designed and implemented during 2001-2002: Enhanced Wetland on Dillon Creek at DC2, Erosion Control Plan for Leeland Addition Watershed, Five Check Dams on Martin Ditch, Nutrient Management Plan for the South Shore Golf Course, and a Sediment Trap in the Bayshore Channel. We recommended designing and implementing the remaining projects at a later date. The schedule is designed to reflect this two-tiered approach.

PROPOSED SCHEDULE FOR DESIGN AND IMPLEMENTATION PROJECTS																
Activity	**2001**				**2002**				**2003**				**2004**			
Quarter:	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Restore Dillon Creek Flow to Johnson Bay Via Lock and Dam											D	D	D		x	
Enchanted Hills Grade and Bank Stabilization											D	D			x	
Enhanced Wetland on Dillon Creek at DC2			D	D	D		x									
Erosion Control Plan for Leeland Addition Watershed					D	D										
Five Check Dams on Martin Ditch					D		x									
Nutrient Management Plan for South Shore Golf Course					D	D										
Bioretention for South Shore Country Club Parking Lot											D	D	D		x	
Sediment Trap in Bayshore Channel			D	D	D		x									

D = Design Phase

X = Construction

REPORT TITLE

TABLE OF CONTENTS

LIST OF TABLES

EXHIBITS

APPENDICES

1.0 INTRODUCTION

1.1 BACKGROUND

In 1999, the Wawasee Area Conservancy Foundation (WACF) was provided a grant under the Indiana Department of Natural Resources (IDNR) Lake and River Enhancement (LARE) program. The grant funds were used to procure the services of a consulting engineering company to perform a lake enhancement engineering feasibility study. The engineering feasibility study follows the 1995 *Lake Enhancement Diagnostic/Feasibility Study for the Wawasee Area Watershed*, which was also funded by the LARE program.

1.2 OBJECTIVE

The objective of this engineering feasibility study is to evaluate the technical, environmental, and social feasibility of WACF-identified projects and to enhance water quality and the environmental value of Lake Wawasee.

1.3 SCOPE OF STUDY

Lake Wawasee has historically exhibited high water quality, however during runoff events, plumes of sediment have been observed to enter the lake at several inlet areas. The 1995 Diagnostic/Feasibility report identified areas of the watershed in which improvements are necessary. These areas include the Enchanted Hills, South Shore, Bayshore, and Leeland Addition subwatersheds. The following are projects included in this engineering feasibility study:

a. Restoration of the original flow channel from the Enchanted Hills through Johnson Bay
b. Grade stabilization structures in Enchanted Hills subwatershed
c. Bank stabilization in Enchanted Hills subwatershed
d. Sediment trap and constructed wetland on Dillon Creek (Enchanted Hills)
e. Erosion control on development sites (e.g., Leeland Addition and South Shore)

f. Sediment traps and/or stormwater retention in the Leeland Addition (Martin Ditch) and South Shore subwatersheds

g. A reconstructed wetland in the Bayshore Swamp

In addition to the projects identified above, the study includes specifies assessments of:

h. Refacing of concrete seawalls with glacial stone

i. Water quality and environmental function of the Mud Lake area

These potential projects and assessments address the community's perceived pollution sources and special concerns.

The engineering feasibility study involves the following 19 tasks:

Task 1:	Identification of Potential Construction Sites
Task 2:	Complete Preliminary Engineering/Calculations
Task 3:	Facilitate Public Meetings Regarding the Proposed Project
Task 4:	Create a Public Information Handout
Task 5:	Project Progress Reporting
Task 6:	Complete Conceptual Drawings
Task 7:	Determine Preliminary Design and Construction Project Cost Estimates and Timelines
Task 8:	Determine Easements and Land Availability
Task 9:	Determine Unusual Physical and/or Social Costs of the Proposed Project
Task 10:	Complete a Flood Stage Analysis if Determined Necessary
Task 11:	Determine Functionality and/or Impact of Proposed Project with Respect to Condition of the Lake
Task 12:	Conduct a Wetland Functional Assessment or Vegetation Survey
Task 13:	Conduct a Survey of Biological and Habitat Integrity Downstream of Proposed Sites
Task 14:	Identify Financing Opportunities
Task 15:	Assess Environmental Effects
Task 16:	Document Justification for Proposed Site Selection
Task 17:	Complete Early Coordination Process for Permits
Task 18:	Complete Engineering Feasibility Report
Task 19:	Update Any Outdated Parameters and Address Information Gaps

1.4 ACKNOWLEDGMENTS

Harza would like to extend appreciation for the assistance give the study team by WACF. Particularly valuable was the assistance and enthusiasm of the WACF's Coordinator, Ms. Heather Harwood, and the Ecology Committee Chairman, Mr. Bob Myers.

Several individuals and agencies provided important data and invaluable guidance: Mr. Michael Massonne of the IDNR's Lake and River Enhancement (LARE) Office, Mr. Sam St. Clair of the Kosciusko County Natural Resources Conservation Service, Ms. Julie Harrold and Mr. Kent Tracey of the IDNR, Mr. William Holder of the Kosciusko County Department of Geographic Information Systems, and Mr. Robert Ladson of the Kosciusko County Highway Department.

This report was written by Ms. Beth Padera, the Project Engineer for this study. Also contributing were Mr. David Pott (Project Manager), Mr. Edward Belmonte (Ecologist), Mr. Justin Bartels (Hydrologist), and Mr. Wade Moore (Hydraulic Engineer).

2.0 DESCRIPTION OF THE STUDY AREA

2.1 LOCATION

Lake Wawasee is located in the northeast section of Kosciusko County in northcentral Indiana (Exhibit 1). Lake Wawasee is generally bordered by Route 13 to the west, the Noble County line to the east, and the Elkhart County line to the north. The lake's center falls at approximately latitude: 41°24'30" and longitude: 85°43'00".

2.2 BACKGROUND REPORTS

Background data on Lake Wawasee includes the following reports:

- *Preliminary Investigation of the Lakes of Kosciusko County* (Hippensteel, 1989), which analyzes land use activities for their impacts on water quality;
- *Enchanted Hills Watershed Evaluation* (SWCD, 1994), which identifies sources of sediment and suggested possible remediation strategies;
- *Lake Enhancement Diagnostic/Feasibility Study for the Wawasee Area Watershed* (Commonwealth Biomonitoring, 1995) which identifies "hot spots" of pollution around the lake, and;
- Several letter reports focusing on specific areas around the lake (NRCS, 1998-1999), including recommendations regarding sediment control at the Bayshore and Leeland Addition areas.

2.3 LAKE PHYSICAL CHARACTERISTICS

A popular site for recreation and fishing, Lake Wawasee is Indiana's largest natural lake. The lake's surface area is 3,400 acres, with a maximum depth of 77 feet and a mean depth of 22 feet. Runoff from the 24,450-acre watershed flows into Lake Wawasee through Turkey Creek, Papakeechie Lake, Bonar Lake, Dillon Creek/Enchanted Hills, and several smaller drainages. Lake Wawasee's watershed drains to the northwest to the St. Joseph River, a tributary of Lake Michigan. The mean hydraulic retention time of water within Lake Wawasee is 3.5 years (Spacie and Loeb, 1990).

2.4 WATERSHED CHARACTERISTICS

The Lake Wawasee watershed is approximately 24,450 acres, one of the largest in the state of Indiana. Streams draining to Lake Wawasee include Turkey Creek, Dillon Creek, Launer Ditch, Norris Branch, South Tributary, Martin Ditch, South Shore Ditch, and the Papakeechie Lake watershed. Land uses in the watershed are summarized in Table 1 and shown in Exhibit 2 (Indiana GAP Database).

Table 1

LAND USE IN LAKE WAWASEE WATERSHED
(Source: Indiana GAP Database)

Land Use	Acres
Urban	785
Agriculture	12,415
Pasture	3,220
Forest/Woodland	3,975
Water	4,055

Agricultural lands comprise 51% of the watershed, with urban areas only contributing 3% of the total watershed area. As the watershed is largely undeveloped, the likely sources of the observed sediment loadings to the lake include the agricultural lands, and natural erosion from the pastures and forested areas. Current and historical agricultural practices and cropping systems are summarized in Section 4.1.1.3

2.5 SOILS

Soils of the watershed consist of sandy and silty loams, the types of which are shown below (Table 2) and in Exhibit 3. The soils in the Lake Wawasee watershed were formed in loamy glacial till of Wisconsinan Age and are on moraines and till plains. Slopes range from 0 to 60 percent (STATSGO database and NRCS 1998).

Table 2

SOIL TYPES IN LAKE WAWASEE WATERSHED
(Source: STATSGO Database)

Soil Type	**Acres**
CROSIER	2,418
GLYNWOOD	1,209
HOMER	1,245
HOUGHTON	3,408
KALAMAZOO	3,517
RIDDLES	714
SPINKS	639
WAWASEE	8,496

Crosier Series

The Crosier series consists of moderately deep to dense till, somewhat poorly drained soils that formed in glacial till on till plains and moraines. Permeability is moderate in the upper part of the subsoil, moderately slow in the lower part, and slow in the substratum. These soils are moderately deep over dense till. Slope ranges from 0 to 4 percent.

Glynwood Series

The Glynwood series consists of very deep soils that are generally moderately deep to dense till. They are moderately well drained soils formed in loamy till of high lime content with a thin layer of loess in some areas. These soils are on till plains and moraines and permeability is slow. Slope ranges from 0 to 40 percent but is typically 2 to 18 percent.

Homer Series

The Homer series consists of very deep, somewhat poorly drained soils formed in loamy outwash material and in the underlying stratified calcareous sand and gravelly coarse sand on outwash plains, terraces, and valley trains. These soils are moderately permeable in the subsoil and very rapidly permeable in the underlying sand and gravel. Slopes range from 0 to 6 percent.

Houghton Series
The Houghton series consists of very deep, very poorly drained soils formed in herbaceous organic deposits more than 51 inches thick in depressions on lake plains, outwash plains, ground and end moraines and on floodplains. These soils have moderately slow to moderately rapid permeability. Slopes range from 0 to 2 percent.

Kalamazoo Series
The Kalamazoo series consists of very deep, well drained soils formed in loamy outwash overlying sand, loamy sand, or sand and gravel outwash on outwash plains, terraces, valley trains, and low lying moraines. These soils have moderate permeability in the upper loamy materials and rapid permeability in the lower sandy materials. Slopes range from 0 to 18 percent.

Riddles Series
The Riddles series consists of very deep, well drained, soils that formed in loamy and sandy till on moraines. Permeability is moderate and slopes range from 0 to 35 percent.

Spinks Series
The Spinks series consists of very deep, well drained soils formed in sandy eolian or outwash material. They are on dunes, and on foot slopes of moraines, till plains, outwash plains, beach ridges and lake plains. These soils have moderately rapid permeability. Slopes range from 0 to 60 percent.

Wawasee Series
The Wawasee series consists of deep, well-drained, moderately permeable soils formed in glacial till on moraines and till plains. These upland soils have slopes ranging from 0 to 18 percent.

2.6 WATER QUALITY

Based on results of watershed sampling and loading allocations, the following water quality observations were made (Commonwealth Biomonitoring, 1995):

- Compared to other small streams draining agricultural areas in Indiana, the tributaries in the Lake Wawasee watershed have low suspended solids and phosphorus concentrations.

- It is estimated that Dillon Creek contributes 17% of Total Phosphorus, 29% of Total Nitrogen, and 34% of Total Suspended Solids to Lake Wawasee (these loadings are approximately twice as much as its watershed area would predict).
- It is estimated that Turkey Creek contributes 40% of Total Phosphorus, 52% of Total Nitrogen, and 44% of Total Suspended Solids to Lake Wawasee (these loadings are almost exactly in proportion to its watershed area).
- It is estimated that South Shore Ditch contributes 1% of Total Phosphorus, 2% of Total Nitrogen, and 10% of Total Suspended Solids to Lake Wawasee (however, the Total Suspended Solids estimate is based upon a stream sample taken during an upstream construction project and it is likely that this does not reflect current conditions, as the construction project has now been completed).

During runoff events, plumes of sediment have been observed to enter the lake at several inlet areas. An attempt was made in the late fall of 2000 to characterize the current flow conditions, and suspended solids and nutrient levels associated with wet weather plumes of sediment. Stormwater samples were taken by WACF staff at four inlets to the lake (Exhibit 4) at 9:30am on November 26, 2000. The samples were analyzed by Sherry Labs of Fort Wayne, Indiana. Results of the Total Phosphorus and Total Suspended Solids analyses are shown below in Table 3.

Table 3

STORM WATER QUALITY SAMPLING DATA
November 26, 2000

Site	Total Phosphorus (mg/L) Method M4500-PE	Total Suspended Solids (mg/L) Method E160.2
Bayshore	<0.4	14
Marineland	<0.4	4
South Shore	<0.4	5
Dillon Creek	<0.4	<2

The Goshen, Indiana weather station recorded that the storm on November 25-26, 2000 produced 0.53 inches of rain during the 18 hours prior to when the samples were taken (Purdue, 2000). This is a very common storm for northcentral Indiana, which will occur, on average, more frequently than once every two months. For perspective, an 18-hour storm that occurs every two months produces 1.22 inches of rain. It is unlikely that the November 25-26th storm was intense enough to reproduce the sediment plumes observed in the past. This is supported by the water quality laboratory results, which indicate low suspended solids and low nutrient levels at all locations sampled.

2.7 ENVIRONMENTAL FUNCTION OF MUD LAKE

The continental divide is approximately 2.5 miles south of Lake Wawasee. The northern side of this watershed boundary, which includes Lake Wawasee and Syracuse Lake, is part of the Lake Michigan drainage. Turkey Creek flows through Wawasee to the Elkhart River, which is tributary to the Saint Joseph River, and Lake Michigan. Lands south of this boundary drain to the Mississippi River via the Tippecanoe, Wabash, and Ohio Rivers. A benefit of being near a continental watershed divide is a limited upstream area that can contribute contaminants to the watershed and Lake Wawasee. This allows watershed improvements to have more influence on lake water quality.

Turkey Creek flows in a northwestern direction from its headwaters in Knapp Lake, through Lake Wawasee, Mud Lake and Syracuse Lake to the confluence with the Elkhart River. Mud Lake connects Lake Wawasee to Syracuse Lake. Lake Wawasee is 3,410 acres and has a maximum depth of 77 feet. Syracuse Lake is 414 acres and has a maximum depth of approximately 34 feet. Mud Lake has an area of 150 acres and a maximum depth of 7 feet.

The entire lakebed of Mud Lake is within the photic zone (the area of light penetration). This allows vegetative communities to become established throughout Mud Lake. The shorelines are colonized by emergent vegetation. Further from shore, floating-leaved communities have become established. Submergent vegetation communities are in the deeper areas of Mud Lake. The surrounding wetlands and emergent shoreline vegetation gives Mud Lake a marsh-like quality.

Mud Lake is more sheltered from winds than the larger lakes on either side. Diminished wind and wave action and the emergent and submergent vegetation communities facilitates the deposition of suspended solids in Mud Lake. The increasing sediment deposits and shallower depths in Mud Lake will continue to support abundant aquatic vegetation.

2.7.1 Water Quality

The following table contains water quality data collected by Harza on September 13, 2000. Dissolved oxygen (DO), water temperature and pH readings were made using a YSI model 6920 water quality data logger.

Table 4

LAKE WATER QUALITY SAMPLING DATA
September 13, 2000

Lake Name	Mud Lake	Syracuse Lake		Lake Wawasee	
	Below surface (0.5 feet)	Below surface (0.5 feet)	Bottom (15 feet)	Below surface (0.5 feet)	Bottom (50 feet)
Northing	41° 25.152'	41° 25.475'		41° 24.486'	
Easting	85° 43.911'	85° 44.171'		85° 43.572'	
Water temp (°C)	20.0	23.0	22.5	22.5	16.0
DO (mg/L)	3.50	7.10	6.40	7.15	0.40
Conductivity (μmhos)	290	320		310	
Secchi disk (ft)	>7	12.5		8.5	
pH	6.79	7.62		7.40	

The deepest location in Mud Lake found during the September survey was seven feet. The Secchi disk was visible on the lakebed in Mud Lake. This places the entire area of Mud Lake within the photic zone, or the area of light penetration.

DO is a measure of the amount of oxygen that is dissolved in the water column and is available to support aquatic life. DO levels near the saturation point generally indicate a healthy environment for fish and other aquatic life. Indiana's surface water quality standard for DO is an average of at least 5 mg/L per day and at no time should levels fall below 4 mg/L. The September 13, 2000 survey measured DO levels in Mud Lake at 3.5 mg/L just below the surface, which is below the Indiana state water quality standard. However the standards are based on stream systems and may not be entirely applicable to shallow lakes. Mud Lake was not thermally stratified, and therefore a DO reading was not taken at the lake bottom. DO in Mud Lake was 40% of saturation. This can cause stress to the fish and macroinvertebrate communities in Mud Lake.

Lake Wawasee was the only one of the three lakes that was thermally stratified during the September 2000 survey. Stratification prevents surface waters from mixing with bottom waters. The waters at the bottom, the hypolimnion, then become oxygen depleted.

Conductivity is the ability of water to carry an electric current and depends on the concentration of dissolved ions. It is an indirect measure of dissolved solids in the water. Typical dissolved solids include salts, organic materials and nutrients. Conductivity levels in all three lakes were low, ranging from 290 to 320 μmhos, indicating low dissolved ion levels.

Water's hydrogen ion concentration is expressed as pH. Measurement below neutral (pH 7.0) indicate higher hydrogen ion concentrations and that the water is acidic. Measurements above neutral indicate low hydrogen ion concentrations and that the water is basic. The three lakes had a pH range of 6.79-7.62. These values are within the Indiana surface water quality standard range of 6.0-9.0. Mud Lake was slightly acidic and Wawasee and Syracuse lakes were slightly basic.

2.7.2 Aquatic Vegetation

Mud Lake has a predominately fine-textured bottom, entirely in the photic zone. Aquatic vegetation can thrive throughout Mud Lake since the sunlight is able to penetrate to the lake bed. Much of the shoreline is colonized floating and emergent vegetation, including duckweed (*Lemna minor*), broad-leaved arrowhead (*Sagittaria latifolia*), water lily (*Nymphaea odorata*) and pond lily (*Nuphar lutea*). The deeper areas of Mud Lake are colonized by submergent vegetation, including pondweed (*Potamogeton pectinatus*) and coontail (*Ceratophyllum demersum*). If the submergent vegetation communities continue to silt in, they will eventually become shallow enough to support emergent vegetation.

2.7.3 Resident Questionnaire

In December 2000, six Mud Lake residents were interviewed over the telephone by Harza staff to obtain their opinion on issues involving Mud Lake (Table 5). While this is a small sample size, attempts to contact other residents were unsuccessful.

Table 5

MUD LAKE RESIDENT SURVEY

Question	Number of Respondents		
	YES	**NO**	**Does not know**
1. Is the water in Mud Lake turbid and muddy during periods of high boat traffic?	3	1	2
2. Is the water in Mud Lake turbid and muddy during periods of low boat traffic?		6	
3. Does the water in Mud Lake appear turbid and muddy on the weekend and then clear up on Monday morning?	2	1	3
4. What are the fastest boat speeds you have observed on Mud Lake?	3 people observed fast boats		
	5 people observed fast personal watercraft		
5. During the busiest times, how many boats would you estimate pass through the channel during one hour?	100, 150 plus, 200 boats/hour		
	2 people said steady traffic		
	1 person had no idea		
6a. If you fish the lake, have you observed any difference in fisheries during periods of high boat traffic?	2	1	3
6b. Have you observed any differences in the fisheries over the past years?	4	2	
7. Have you observed any positive or negative changes in wildlife (aquatic mammals, birds, reptiles) communities over the past years?	1 person observed fewer herons/cranes		
	3 people observed increase in Canada geese		
	3 people observed increase in muskrats		
	1 person observed fewer snakes		
	2 people observed no changes		
8. Have you observed any positive or negative changes in aquatic vegetation over the past years?	5 people observed an increase in vegetation		
	1 person said there has been no change		

Of the residents questioned, more people believed that Mud Lake's turbid and muddy quality is a result of boat activity. All of the residents have observed fast moving craft on Mud Lake and 5 of 6 mentioned personal watercrafts being among the fastest types of watercraft observed on the lake.

Twice as many people (2 to 1) believe that fish are affected during periods of high boat traffic, and twice as many people (4 to 2) believe there has been degradation in the fisheries of Mud Lake over the past several years.

Half of the people questioned have observed increases in Canada geese and increases in muskrats. Five out of six of the people questioned have observed an increase in the amount of aquatic vegetation.

2.8 REFACING SEAWALLS WITH GLACIAL STONE ASSESSMENT

The demonstration project of refacing of the seawall on the north shore of Lake Wawasee with glacial stone has not yet taken place. The Indiana Department of Natural Resources (IDNR) Division of Fish and Wildlife has collected pre-construction data along the north shore seawall. The IDNR's pre-construction data includes: fishery survey, sediment sampling, and qualitative observations of macrophytes and algae.

The results of refacing the north shore seawall are unknown. It is anticipated that the placement of glacial stone will improve the present aesthetics, water quality and shoreline habitat conditions along the north shore in Lake Wawasee.

3.0 LAKE ENHANCEMENT ALTERNATIVES

3.1 APPROACH

The purpose of an engineering feasibility study is to identify, screen, and compare project alternatives and to select one or more alternatives for further study or design. Alternative methods for enhancing Lake Wawasee were evaluated using a two-level procedure, with the depth of study increasing as the list of alternatives narrowed to those most feasible. The evaluation involves:

Identification and Screening – A comprehensive list of reasonable lake enhancement methods was compiled. Alternatives that were obviously not applicable to Lake Wawasee, had unacceptable environmental impacts, or unproven technology were eliminated from further consideration.

Feasibility Evaluation – Alternative methods were evaluated for technical feasibility for enhancing Lake Wawasee. The alternatives remaining for evaluation at this level of study were prioritized for implementation based on effectiveness and cost.

3.2 IDENTIFICATION AND SCREENING

For the purposes of lake enhancement, we have focused our study on alternative methods to reduce sediment loadings to Lake Wawasee. The locations of problem areas, or sources, were identified by the WACF and were incorporated into the engineering feasibility study (Exhibit 5): Enchanted Hills, South Shore, Bayshore/Marineland, and Leeland Addition. A comprehensive list of lake enhancement measures was generated from compiling the recommendations of past investigators, recent workshops held with lake users, and the best professional judgment of the consulting team.

The site selection memorandum (Harza, 2000) identified alternatives for each problem area identified by the WACF (Appendix A). A summary of selected potential pollution control projects is included below.

3.2.1 Restoration of the Original Flow Channel from the Enchanted Hills to the Johnson Bay Wetland

When the Enchanted Hills subdivision was developed, Dillon Creek was diverted through the channels and into Lake Wawasee near Cedar Point. Previously, Dillon Creek flowed into Johnson Bay through the wetland system to the north and east of the bay. The water quality benefits of rerouting Dillon Creek through the Johnson Bay wetland include reduced sediment or nutrient load entering Lake Wawasee from the Dillon Creek/Enchanted Hills area due to slowing of the water and plant uptake of nutrients in the wetland, and greater flushing potential for the Enchanted Hills channels.

In order to restore flow to Johnson Bay, the water level in the Enchanted Hills channels must be raised. Alternatives to raise the water level, while maintaining navigation include:

- A lock and dam at the outlet of the channels to Lake Wawasee
- A flood gate at the outlet to Lake Wawasee

Both of these alternatives will be evaluated in our feasibility study.

3.2.2 Grade and Bank Stabilization in the Enchanted Hills Subwatershed

The Enchanted Hills subdivision consists of homes (some atop steeply graded hills) abutting man-made channels. The channel slopes throughout the subdivision are eroding and are sources of sediment to Lake Wawasee. Large sediment plumes have been observed at the inlet to the lake. Harza performed a lot-by-lot assessment of the subdivision to identify areas in need of bank and grade stabilization, as further described in Section 4.2. We characterized erosion as “severe” (unprotected with moderate to steep slopes, some vegetation, and severe erosion), “moderate” (unprotected with moderate to steep slopes, vegetation, and moderate erosion), “slight” (unprotected with gentle slopes, vegetated, and moderate erosion) and “potential” (unprotected with gentle to steep slopes, vegetated, and no current erosion). Shoreline categorized as “severe” totaled approximately 5,310 lineal feet, areas categorized as “moderate” totaled approximately 2,145 lineal feet, areas categorized as “slight” totaled approximately 2,670 lineal feet, and areas of categorized as “potential” totaled approximately 4,269 lineal feet.

Various types of erosion control are available, including:

- Fiber rolls;
- Emergent and herbaceous plantings;
- Sheetpiling;
- Concrete seawalls; and
- Boulders and stone.

We recommended that the areas of severe erosion be the initial focus of the grade and bank stabilization improvements, with the highest priority given to shoreline that takes the most wave/wake energy (i.e. entrance to channels from Lake Wawasee, and channel intersections). Each area of severe erosion will be evaluated for the most feasible bank stabilization measure.

3.2.3 Sediment Trap/Constructed Wetland on Dillon Creek

This alternative would provide for detention and water quality treatment upstream of Enchanted Hills on Dillon Creek. Reducing flow rates and volumes and increasing detention time would lead to greater sedimentation and nutrient removal. A sediment trap, consisting of a settling basin with a sheetpile dam, is one alternative for Dillon Creek. A constructed wetland, consisting of a settling basin, sheetpile dam, and shallow pool with wetland vegetation, is another alternative. Both the sediment trap and constructed wetland require regular sediment removal and maintenance.

Three sites on Dillon Creek, DC1, DC2, and DC3, were evaluated for biological integrity and water quality (Appendix A). All three sites showed comparable biological characteristics, and are characterized as forested wetlands.

As the biological integrity of each site is similar, we recommended investigating the feasibility of a constructed wetland at DC2, due to the superior physical aspects of the site. The DC2 site is wide and flat, compared to sites DC1 and DC3, and is likely a source area for sediment. Placing a constructed wetland at DC2 would allow settling of sediment and stabilization of the area during storm flow, and straightforward access for maintenance.

3.2.4 Erosion Control on Development Sites and Sediment Trap and/or Stormwater Retention in the Leeland Addition (Martin Ditch)

Martin Ditch collects stormwater runoff from surrounding agricultural areas, and flows to Lake Wawasee. The fields near Martin Ditch are classed as highly erodible lands and were included in the United States Department of Agriculture's Conservation Reserve Program (CRP) at one time. The contract has since expired, and the fields have been returned to cultivation. Reestablishing these fields in the CRP program would reduce the amount of sediment entering channels at the Leeland Addition. Erosion of the streambed between County Road 800 E and the Leeland Addition Road is also likely a source of sediment to the channels (NRCS, 1999). Stream bank stabilization measures were recommended for Martin Ditch by the NRCS. Channel hardening, placing riprap along channel bottom and banks, is an option to reduce erosion of the streambed. Regrading, opening the canopy, and planting the banks with native herbaceous vegetation would also stabilize the banks and reduce stream bank erosion. Both of these options would require disturbance of the natural, forested setting of Martin Ditch. Constructing a series of check dams, or riprap structures, at several locations in the streambed of Martin Ditch would dissipate energy and reduce the potential for streambed erosion to occur.

The south side of the South Drive is a potential structural BMP site. Construction there would require disturbance of a high quality hardwood forest. Alternatively, a sediment trap in the channel north of South Drive is also an option for sediment removal. This alternative may have landowner opposition, navigational, and land acquisition obstacles. Previous sources of sediment, such as the construction of the new Wawasee Middle School and the sanitary sewer borrow area, have since been vegetated.

We recommended pursuing source control on surrounding farm and residential properties. In addition, a series of riprap check dams on Martin Ditch and a sediment trap in the channel north of South Drive will be investigated. These options were selected for feasibility study because they minimally disturb the wooded area south of South Drive.

3.2.5 Erosion Control on Development Sites and Sediment Trap and/or Stormwater Retention in the South Shore Subwatershed

The South Shore Area consists of a ditch draining runoff from the South Shore Golf Course and Route 13, and flowing to Lake Wawasee. Based on previous sampling results

(Commonwealth Biomonitoring, 1995), it is likely that fertilizers and other chemicals used to treat the golf course are entering the South Shore Ditch via stormwater runoff. Nutrient management planning by the South Shore Country Club should reduce nutrient loadings. There is a small existing wetland area to the west of Route 13 owned by the South Shore Country Club, and it may be possible to improve the existing wetland to assimilate more nutrients. This may require permits from the Army Corps of Engineers and the County Surveyor, and land may need to be acquired. Severe bank erosion has been observed in the streambed to the east of Route 13, and it is likely a minor source of sediment to the lake. Opening the canopy and planting the banks with native herbaceous vegetation would serve to stabilize the banks and reduce stream bank erosion. Due to the small area, regrading may be difficult.

Creating a wetland east of Route 13 would provide additional nutrient removal capacity. Due to the limited area, it may not be feasible. Another option would be to provide bioretention at this location, which would be comprised of plantings covered with hardwood mulch. Water flowing through the ditch would be slowed and would filter through the hardwood mulch/plantings mixture removing sediment and nutrients. Land easements would need to be acquired, as well as permits. In the past, construction projects to the west of Route 13 were causing sediment to enter the ditch and subsequently enter Lake Wawasee. These construction projects are now complete, and this source is no longer significant.

We recommend a feasibility evaluation of source control at the golf course. In addition, the sediment trap and bioretention options should be investigated. The site to the east of Rte 13 was selected as to provide the least amount of disturbance to the existing wetland west of Rte 13.

3.2.6 Reconstructed Wetland in the Bayshore Swamp

The Bayshore Area consists of a residential area developed around dredged boat channels to the lake. The Bayshore channel is fed by a ditch that collects agricultural runoff also from fields to the south of Hatchery Road. Sediment plumes have likewise been observed where the Bayshore channel enters Lake Wawasee. There is an existing wetland system to the south of Hatchery Road that might be reconfigured to increase sediment removal. The wetland spans CR 850E, with a culvert under the road. Increasing sediment trapping efficiency in this wetland would entail greater detention, either by increasing volume, or flow path length. Increased volume can be obtained by creating a sheetpile impoundment at the outlet of the wetland to the west of CR 850E before the water enters the culvert under the road. This would contain the water to the west of the road, and release it slowly through the culvert the wetland to the east of CR 850E. Another option would be to route runoff through the recreational ponds west of the road to slow the water before entering the wetlands. The stream to the south of the ponds could be diverted first into the eastern-most pond and then back into the wetland to the north as suggested by NRCS (1998). This would allow the sediment to settle out before reaching the wetlands, and subsequently, Lake Wawasee. Both of these options involve reconstruction of existing wetlands, and would require permits from the Army Corp of Engineers, IDNR, and the County Surveyor. Both options would also require the land to be acquired or leased. Should alterations of the existing ponds be selected, the owner would have to be amenable to the potential impairment of the ponds for recreational uses such as swimming or fishing. Alternatively, an in-lake sediment trap in the channel is also an option for sediment removal. This alternative also presents landowner, navigational, and regulatory obstacles.

At this time, we recommend investigating the impoundment of the wetland west of CR 850E. This option will back up the water and allow settling of sediment, without the loss of the recreational benefits of the ponds. We also recommend investigating the in-channel sediment trap at Bayshore, which would provide sediment removal while allowing easy access for maintenance and sediment removal.

4.0 FEASIBILITY ANALYSIS

4.1 RESTORATION OF THE ORIGINAL FLOW CHANNEL FROM THE ENCHANTED HILLS TO THE JOHNSON BAY WETLAND

4.1.1 Preliminary Design

The Johnson Bay Wetland slopes from its northern boundary along the Baltimore & Ohio Railroad and its western boundary along East Wawasee Drive down to the lake shoreline. The average ground elevation at the high end is between 860 and 870 feet. Lake level is approximately El. 859.9 feet above mean sea level.

The historical source of water for these wetlands included the watershed currently draining to the Enchanted Hills channels via Dillon Creek. The natural ridge along the lake shore between the channels and the lake would indicate that Dillon Creek and its tributaries once flowed parallel to the lake shore before emptying into the lake through the wetland.

In order to restore this flow, at least partially, the water level within the channels must be raised to a level just above the ground level in the wetland along Wawasee Drive. Exhibit 6 shows a profile along Dillon Creek, through the channels and across the wetland to the lake. It is postulated that the construction of the channels interrupted the natural flow path to the wetland. By raising the water level within the channels this flow path can be restored.

4.1.1.1 Flow Path Water Levels

Water levels in Syracuse Lake prior to 1965 generally fluctuated between El. 857.5 in the fall and winter and El. 859.0 during the spring and early summer with the average water level about El. 858.3. In 1965, the control of the outlet of the lake was modified so that the fluctuation was reduced to between El. 858.0 and El. 859.0 with an average of about El. 858.7 as shown in Exhibit 7. More recently the fluctuation has been even smaller - between 858.5 and 859.0 with an average of about El. 858.7, as seen in Exhibit 7.

In order to provide flow to the Johnson Bay Wetland the water level in the channels would need to be raised to about El. 861±. This is about 2.3 feet above the average water level of the lake and roughly two feet above the normal seasonal high water level.

4.1.1.2 Lock and Dam

One method to raise the water level in the channels while still maintaining a connection to the lake would be to construct a lock and dam at the Enchanted Hills outlet to the lake. A box culvert between the northernmost spur of the channels and the Johnson Bay wetland would allow flow to pass under Wawasee Drive. Exhibit 9 shows the general location of the two structures required. The level of the box culvert will be set slightly lower than the level of the dam so that base flows would always pass through the wetland before entering the lake. During storm events the flow will be split between flowing through the box culvert and over the dam. For very large events the majority of the flow will be over the dam section.

The lock is required so that the level can be maintained at the El 861±. Individual boaters can operate the lock without the need for supervision. If for some reason the both lock valves are opened simultaneously the upper pool could be lost but it would take some time, as the valves are quite small. Periodic inspections can avoid this problem.

Exhibit 10 shows a plan view of the lock and dam. The dam is a sheet pile wall with rip rap placed on the downstream side to protect the structure from erosion during flood events. The lock consists of sheet pile walls, prefabricated mitre gates with integral filling/emptying valves. Guide walls upstream and downstream of the lock can be constructed from sheet pile or piles with whalers.

4.1.1.3 Flood Gate

An alternative to the lock and dam is to construct a floodgate at the same site. With this alternative the water level in the channels remains at the same level as the lake. During floods, however, a gate is lowered that forces the water level in the channels to rise which in turn forces a portion of the flow to box culvert and then to the wetland. Low flow events would not be diverted to the wetland as they are with the lock and dam alternative.

Although the operation of the gate could be automated it would be more cost effective, because of the infrequent use, to operate it manually. When a flood of a magnitude sufficient to fill the channels has been forecast the gate can be closed. After the flood event, the gate is raised to empty the channels and boaters can then use the channels normally. During flood events with the gate closed boaters will not be able to leave or enter the channels.

The gate occupies the same position as the lock in Exhibit 10 but does not require nearly as much sheet piling. Also, the approach and departure guide walls can be much shorter because it will not be necessary for boats to tie up to them.

4.1.2 Lake Response

Velocities in the Enchanted Hills channels during storm flows will be reduced by about one-third due to the higher elevation of the water level. This effect will slightly reduce erosion of the channel banks, and may slow water enough to allow sediment to settle out in the channels. The major water quality benefit of this alternative, however, is the filtering effect of the wetland. Johnson Bay Wetland would remove a significant portion of the sediments and nutrients entering it through the surrounding watershed.

4.1.3 Permit Requirements

Several different state and federal permits and approvals are required for construction of the lock and dam/floodgate in the Enchanted Hills channels and development of a channel to Johnson Bay (Appendix B). The Indiana Department of Natural Resources requires a joint permit application for construction within a floodway of a stream or river, navigable waterway, public fresh water lake, and ditch reconstruction. One of the permits listed under the joint permit application is the Lake Preservation Act. Lake Preservation Act states that no person may change the level of the water of shoreline of a public freshwater lake by excavating, filling in, or otherwise causing a change in the area or depth or affecting the natural resources scenic beauty or contour of the lake below the waterline or shoreline, without first securing the written approval of the DNR. A written permit from the department is also required for construction of permanent structures within the waterline or shoreline of a public freshwater lake. It will also be necessary to petition the Kosciusko County Circuit Court for permission to construct the Lock and Dam or the Flood Gate, and to raise the legal level of the lake.

The Indiana Department of Environmental Management requires a Section 401 Water Quality Certification (WQC) to conduct any activity that may result in a discharge into waters of the United States. In general, anyone who is required to obtain a permit from the U.S. Army Corps of Engineers (USACE) to engage in dredging, excavation, or filling activities must obtain a WQC. The followings are examples that would likely require a USACE permit and WQC: dredging a lake, river, stream, or wetland; filling a lake, river, stream, or wetland; bank stabilization; pond construction in wetlands; and roadway/bridge construction projects involving water crossings.

The Detroit USACE requires permits authorizing activities in, or affecting, navigable waters of the United States, the discharge of dredged fill material into waters of the United States, and the transportation of dredged material for the purpose of dumping into ocean waters. Waters of the U.S. also include adjacent wetlands and tributaries to navigable waters of the U.S. and other waters where the degradation or destruction of which could affect interstate or foreign commerce.

A Dam Safety Permit is required by the IDNR if the area of concern meets at least one of the following three requirements: watershed area of 1 square mile or greater, dam height of at least 20 feet, and a detention volume of 100 acre-feet or greater. This permit may be required as the Enchanted Hills watershed drains an area of approximately 5.5 square miles.

4.1.4 Easements and Land Availability

Property owners of areas potentially affected by restoration of the original flow channel from Enchanted Hills to the Johnson Bay Wetland were identified. Property owner information was obtained from the Property Boundary Plat Maps developed by the Department of Geographic Information Systems of Kosciusko County.

A culvert to Johnson Bay would have the potential to impact one section of the East Wawasee Drive easement, lots on the channel east of East Wawasee Drive including land parcel 007-047-108 owned by Columbia Realty Corporation, P.O. Box 52, North Manchester, Indiana 45962, land parcel 007-047-109 owned by Cecelia Snyder, 9758 East Rock-A-Bye Road, Cromwell, Indiana 46732, and land parcel 007-047-110 owned by Billie Vernon Reynolds, 66082 SR 15, Goshen, Indiana 46526, and the wetland to the west of East Wawasee Drive which is parcel 007-044-005 owned by Mr. And Mrs. Pete Nicholas, 7654 E. Eli Lilly Road, Syracuse, Indiana 46567. The flood gate will be in the channel of Enchanted Hills, adjoining parcel 007-050-911 owned by Bethelene Cramer, 52985 Glenmore, Elkhart, Indiana 46514 and parcel 007-050-686 owned by James and Janice Sroufe, 11562 North Fascination Way, Cromwell, Indiana 46732.

4.1.5 Unusual Physical and/or Social Costs

Through the course of public meetings, residents of Lake Wawasee expressed concern that recommended solutions provide not only water quality benefits, but environmental and aesthetic benefits as well. Restoration of the original channel of Dillon Creek is environmentally based, however the potential negative impacts to the Johnson Bay Wetland are considerable. While routing flow through the wetland will result in enhanced lake water quality, the project may alter the habitat and quality of the wetland. If this option were to be implemented, a sediment trap should be considered for construction in the channel prior to outlet into the wetland. This would reduce the sedimentation impacts to the Johnson Bay Wetland. In addition, according to the Kosciusko County Highway Department, construction on East Wawasee Drive will commence during summer 2001. Elevations and drainage patterns used in this study may be altered as a result of this construction.

In addition, responsibility for the maintenance and operation of the lock and dam or flood gate will fall upon the boaters requiring access between Lake Wawasee and the Enchanted Hills channels. Opening and closing the lock will require additional time and effort for those boaters entering or exiting the channels. Maintenance costs are estimated at 10% of the capital costs of construction.

4.1.6 Johnson Bay Wetland Characterization

Harza reconnoitered vegetation communities in Johnson Bay. Dominant species are listed in Table 6. No endangered, threatened or rare species were found. Obligate wetland species, facultative wetland species, facultative upland species and upland species were found there, testifying to the variety of habitats and hydrologic regimes present. We characterize the Johnson Bay wetland as a freshwater marsh, with emergent aquatic plants growing in a permanent to seasonal shallow water. Scrub-shrub wetland communities exist both within and bordering the emergent community.

Table 6

JOHNSON BAY WETLANDS DOMINANT VEGETATION SPECIES

Common Name	Latin Name	Wetland Indicator Category
Broad-Leaved Arrowhead	Sagittaria latifolia	OBL aquatic - emergent
Pond Lilly	Nuphar lutea	OBL aquatic - emergent
Water Lilly	*Nymphaea odorata*	OBL aquatic - emergent
Water Shield	*Brasenia schreberi*	OBL aquatic - emergent
Narrow-Leaf Cattail	*Typha angustifolia*	OBL
Buckbean	*Menyanthes trifoliata*	OBL
Marsh Fern	*Thelypteris thelypteroides*	FACW+
Spotted Touch-Me-Not	Impatiens capensis	FACW
Nuttall's Waterhemp	*Amaranthus rudis*	FACW
Sensitive Fern	*Onoclea sensibilis*	FACW
Silver Maple	*Acer saccharinum*	FACW
Green Ash	*Fraxinus pennsylvanica*	FACW
Red-Osier Dogwood	*Cornus stolonifera*	FACW
River-Bank Grape	*Vitis riparia*	FACW-
Eastern Cottonwood	*Populus deltoides*	FAC+
Smooth Rose	*Rosa blanda*	FACU
Black Walnut	*Juglans nigra*	FACU

Key:
OBL = obligate wetland species; probability of occurrence in wetlands: > 99%
FACW = facultative wetland species; probability of occurrence in wetlands: 34 to 66%
FACW+ = facultative wetland species; probability of occurrence in wetlands: 51 to 66%
FACW- = facultative wetland species; probability of occurrence in wetlands: 34 to 50%
FACU = facultative upland species; probability of occurrence in wetlands: 1 to 33%
FACU+ = facultative upland species; probability of occurrence in wetlands: 17 to 33%
FACU- = facultative upland species; probability of occurrence in wetlands: 1 to 16%
UPL = upland species; probability of occurrence in wetlands: <1%

4.1.7 Estimated Cost of Construction

The probable cost of construction for the lock and dam is about $202,000 (Table 7). For materials costs less than $100,000, engineering fees were calculated at 15% of the materials cost. For materials costs above $100,000 engineering fees were calculated at 10% of the materials cost. Services during construction were estimated at 10% of the materials cost. A 25% contingency was applied to the subtotal of materials, engineering, and services during construction. This estimate is based on 2001 dollars.

Table 7

COST ESTIMATE FOR LOCK AND DAM

Item	**Cost**	**Unit**	**Qty**	**Total**
Dewatering of Work Area	$ 3,000	lump sum	1	$3,000
Lock Gates and Valves	$30,000	lump sum	1	$30,000
Sheet Pile	$ 20	Square foot (installed)	2500	$50,000
Fill	$ 20	Cubic yard (small jobs)	35	$ 700
Rip Rap	$ 35	ton	12	$ 400
Culvert (4' x 8')	$ 250	ft	100	$25,000
Road Restoration	$10,000	lump sum	1	$10,000
Mobilization/Demobilization	$5,000	lump sum	1	$5,000
Clearing and Grubbing	$ 3,000	lump sum	1	$3,000
Restoration	$ 3,000	lump sum	1	$3,000
Surveying	$ 2,000	lump sum	1	$2,000
Services During Construction @ 10%				$14,000
Engineering @ 10%				$14,000
Subtotal				**$161,000**
Contingency @ 25%				$41,000
Total				**$202,000**

The probable cost of construction for the floodgate is about $152,000 (Table 8). For materials costs less than $100,000, engineering fees were calculated at 15% of the materials cost. For materials costs above $100,000 engineering fees were calculated at 10% of the materials cost. Services during construction were estimated at 10% of the materials cost. A 25% contingency was applied to the subtotal of materials, engineering, and services during construction. This estimate is based on 2001 dollars.

Table 8

COST ESTIMATE FOR FLOODGATE

Item	**Cost**	**Unit**	**Qty**	**Total**
Dewatering of Work Area	$ 3,000	Lump sum	1	$3,000
Flood Gate	$15,000	Lump sum	1	$15,000
Sheet Pile	$ 20	Square foot (installed)	1400	$28,000
Fill	$ 20	Cubic yard (small jobs)	35	$ 700
Rip Rap	$ 35	Ton	12	$ 400
Culvert (4' x 8')	$ 250	Ft	100	$25,000
Road Restoration	$10,000	Lump sum	1	$10,000
Mobilization/Demobilization	$5,000	Lump sum	1	$5,000
Clearing and Grubbing	$ 3,000	Lump sum	1	$3,000
Restoration	$ 3,000	Lump sum	1	$3,000
Surveying	$ 2,000	Lump sum	1	$2,000
Services During Construction @ 10%				$10,000
Engineering @ 15%				$15,000
Subtotal				$121,000
Contingency @ 25%				$31,000
Total				**$152,000**

4.1.8 Recommendation

We recommend the lock and dam, because it restores all flow to Johnson Bay, flood forecasting is not required, and it maintains navigation during high water.

4.2 GRADE AND BANK STABILIZATION IN ENCHANTED HILLS

4.2.1 Preliminary Design

The Enchanted Hills subdivision consists of homes abutting channels. Some of these homes are atop steeply graded hills. The channel slopes throughout the subdivision are eroding and are sources of sediment to Lake Wawasee. Large sediment plumes have been observed at the inlet to the lake. Harza performed a lot-by-lot assessment of the subdivision to identify and characterize areas in need of bank and grade stabilization (Exhibit 11). We characterized erosion as "severe" (unprotected with moderate to steep slopes, some vegetation, and severe erosion), "moderate" (unprotected with moderate to steep slopes, vegetation, and moderate erosion), "slight" (unprotected with gentle slopes, vegetated, and moderate erosion) and "potential" (unprotected with gentle to steep slopes, vegetated, and no current erosion). Shoreline categorized as "severe" totaled 5,310 lineal feet, areas categorized as "moderate" totaled 2,145 lineal feet, areas categorized as "slight" totaled 2,670 lineal feet, and areas of categorized as "potential" totaled 4,270 lineal feet.

Erosion occurs whenever the forces of wind and water exceed the ability of shoreline soils and vegetation to hold the bank in place. A number of factors affect the rate and severity of shoreline erosion, including: soil type and structure, surface and subsurface drainage, vegetation growth and management, seasonal water level and temperature variations, water depth and wave energy, and activities of certain animal species.

Various types of erosion control are available, including fiber rolls, emergent and herbaceous plantings, sheetpiling, concrete seawall, and boulders and stone. Several homeowners have already implemented these techniques in the Enchanted Hills subdivision. Treatments such as fiber rolls, and emergent and herbaceous plantings will require some, if not significant, maintenance and may not be completely effective in areas of high wave/wake energy. Installation of sheetpiling or concrete seawall would provide a structural treatment capable of protecting shoreline under all conditions; it would require no maintenance but would reduce natural habitat.

Due to their wave reflectance properties, structural approaches may cause more severe erosion to occur on adjacent non-protected shoreline. A critical requirement for erosion control is protection of the "water-to-shore" interface, between 0 and 12 inches below water level. Inadequate protection of this “toe” zone can be a significant cause of bank erosion. In moderate to high wave exposure conditions, toe protection must be provided in conjunction with slope protection in order to control erosion and stabilize the slope. Shoreline protection measures considered applicable for use at Enchanted Hills are described below (cost estimates include bank regrading and planting).

4.2.1.1 Sheetpiling

Steel or vinyl sheetpiling is an effective toe protection measure, particularly for deep-water applications (greater than two or three feet). It can be placed with the top of piling just below water level, so that it is not visually intrusive (Exhibit 12). Sheet piling provides not only adequate coverage, but also durable protection for the areas selected. Sheet piling was chosen for the most severely eroding and heavily traveled channel areas in Enchanted Hills. These areas include the entrance to the channel system (ES1) as well as the major intersection within the system (including erosion survey areas ES6 and ES13) (Exhibit 11).

4.2.1.2 Fiber Rolls

A fiber roll consists of coconut fibers enclosed in a woven rope mesh. The fiber roll typically comes in six or 12-inch diameters that can, if desired, be interplanted with wetland species of plants. A fiber roll is considered a temporary toe protection measure as it tends to biodegrade in five to seven years. The long-term protection is provided by the interplanted species (Exhibit 12). The emergent fiber roll remediation strategy was chosen for the erosion study area labeled ES5 (Exhibit 11). In an adjacent lot, there has already been a fiber roll installed as a demonstration project. This method has proven to be effective.

Given that vegetation ultimately provides the stabilization, herbicide application programs at Enchanted Hills should be continually reevaluated.

4.2.1.3 Herbaceous and Emergent Vegetation

Herbaceous vegetation, consisting of plantings along the shoreline, has been identified as a solution for eroded slopes in areas intended to have a ‘manicured’ image. Traditional turf grass has shown to erode the channel banks, therefore specific dwarf species suited to different hydrologic regimes will be selected and planted. When used in conjunction with appropriate toe protection (e.g., cobbles, sheetpiling, or emergent plants), deep-rooted herbaceous vegetation has been shown to stabilize slopes. Two variations exist for this treatment (Exhibit 12). For moderately eroded slopes, the toe is stabilized with stone and the herbaceous materials vegetate a cut slope, or the face of an eroded slope that has been 'smoothed' out and faced with topsoil. For severely eroded slopes, sheetpiling below water level is used to stabilize the shoreline toe and support the herbaceous vegetation on a fill slope. Both variations require upslope drainage facilities to limit seepage and prevent slumping. For erosion study areas ES8 and ES9 (Exhibit 11), the planting of herbaceous vegetation was selected.

Rooted plants in nearshore water areas can reduce wave energy before reaching the shore. These plants can be submergent, emergent, or floating species, however native plants with strong root systems are likely to provide the best shoreline protection. Emergent plants provide natural habitat, and include such species as cattails, rushes, bulrushes, and arrowhead. While the cost of emergent plantings as a remediation technology is relatively low, they offer little resistance in areas of high wave or wake energy. The channels in Enchanted Hills are presently treated with herbicides, and therefore any emergent planting installed for shoreline protection may be damaged by these plant control measures. For this reason, emergent vegetation is not recommended for the channels of Enchanted Hills.

4.2.1.4 Boulder and Stone

Boulders and small stone (two to four inches in diameter) placed along the shoreline provide protection from wave action (Exhibit 12). There is little maintenance associated with the technology, and the stone provides habitat for aquatic life along the shoreline. One drawback of the boulders and stone can be a rather sterile appearance. To compensate for this, the following approaches can be taken: (1) the boulders and stone can be dark-colored, and (2) the boulders and stone will not be placed above the normal pool elevation. Both approaches serve to reduce the visual impacts of the stone.

For Enchanted Hills, placement of boulders and stone was selected as a remediation strategy for the corners of erosion study areas ES11 and ES14 (Exhibit 11). These corners are subject to much wave energy as they are at a major intersection in waterways.

4.2.1.5 Concrete Seawalls

A seawall is a structure that is built to protect the landward side of a slope from damaging wave action or currents. Seawalls may be constructed with concrete, steel sheet piles, or wood. Because of the high cost and visual intrusiveness of concrete seawalls, this was not selected for any part of the study area in Enchanted Hills.

4.2.2 Lake Response

Shoreline erosion at Enchanted Hills is a source of sediment loading to the lake. It is difficult to accurately determine the amount of shoreline erosion occurring at a lake due to variables that influence the erosion processes, such as soil structure, animal activities, wave action, fluctuating lake levels, human interference, and other factors.

Without historical field information, it is difficult to determine the amount of shoreline erosion occurring at Enchanted Hills. A Clean Lakes Phase I assessment was done on Herrick Lake in DuPage County Illinois in 1994. It is a small glacial lake that receives recreational boat traffic and has experienced shoreline erosion problems. In the absence of site-specific erosion information for Enchanted Hills, Herrick Lake serves as an adequate model for estimating the sediment loading at Enchanted Hills. Shoreline erosion was estimated at Herrick Lake to produce 40 lbs/lineal foot of TSS per year for areas undergoing "severe" erosion (Hill et al., 1994). The erosion factor from Herrick Lake was assumed to be similar to the "severe" erosion rates occurring at Enchanted Hills. A factor of 30 lbs/lineal foot per year was applied to shoreline eroding at a "moderate" rate, and a factor of 20 lbs/lineal foot per year was applied to the shoreline eroding at a "slight" rate (Hill et al., 1994). Table 9 outlines the estimated amount of sediment entering Lake Wawasee from the erosion of the Enchanted Hills channels.

Table 9

SEDIMENT LOADING FROM EROSION OF ENCHANTED HILLS CHANNELS

Erosion Type	Erosion Length (lineal feet)	Erosion Factor (lbs/lineal feet/year)	Sediment Loading (lbs/year)
Severe	5,310	40	212,400
Moderate	2,145	30	64,350
Slight	2,670	20	53,400
Total	**10,125**	**-**	**330,150**

Therefore, by providing bank and grade stabilization measures for the areas of "severe" erosion occurring in the Enchanted Hills channels, the sediment load to Lake Wawasee from the channels will be reduced by 212,400 lbs of sediment per year, or 64% of the total loading from this source.

4.2.3 Permit Requirements

Several different state and federal permits and approvals are required by the grade and bank stabilization project in Enchanted Hills (Appendix B). The Indiana Department of Natural Resources requires a joint permit application for construction within a floodway of a stream or river, navigable waterway, public fresh water lake, and ditch reconstruction. One of the permits listed under the joint permit application is the Lake Preservation Act. Lake Preservation Act states that no person may change the level of the water of shoreline of a public freshwater lake by excavating, filling in, or otherwise causing a change in the area or depth or affecting the natural resources scenic beauty or contour of the lake below the waterline or shoreline, without first securing the written approval of the DNR. A written permit from the department is also required for construction of marinas, new seawall, and seawall refacing. There is a potential problem regarding the types of materials that may be used to stabilize the shoreline. Based on the aerial photograph in Exhibit 11, it appears that most of the channel banks are unprotected. If the distance between the existing bulkhead (concrete, sheet pile, timber) is greater than 250 feet, these unprotected areas will be classified as either an "area of special concern" or a "significant wetland." Therefore, concrete or steel sheet pile may only be used in areas landward of the legal shoreline. Department staff is working on a proposed modification to this rule, but for the time being it must be applied as it currently exists.

The Indiana Department of Environmental Management requires a Section 401 Water Quality Certification (WQC) to conduct any activity that may result in a discharge into waters of the United States. In general, anyone who is required to obtain a permit from the U.S. Army Corps of Engineers (USACE) to engage in dredging, excavation, or filling activities must obtain a WQC. The followings are examples that would likely require a USACE permit and WQC: dredging a lake, river, stream, or wetland; filling a lake, river, stream, or wetland; bank stabilization; pond construction in wetlands; and roadway/bridge construction projects involving water crossings.

The Detroit USACE requires permits authorizing activities in, or affecting, navigable waters of the United States, the discharge of dredged fill material into waters of the United States, and the transportation of dredged material for the purpose of dumping into ocean waters. Waters of the U.S. also include adjacent wetlands and tributaries to navigable waters of the U.S. and other waters where the degradation or destruction of which could affect interstate or foreign commerce.

4.2.4 Easements and Land Availability

Property owners of areas in need for bank and grade stabilization in the Enchanted Hills subwatershed were identified. Property owner information was obtained from the Property Boundary Plat Maps developed by the Department of Geographic Information Systems of Kosciusko County. Stream bank stabilization in the subwatershed would potentially impact 224 land parcels, which are listed in Appendix C, Enchanted Hills Property Owners.

4.2.5 Unusual Physical and/or Social Costs

We recommend that each property owner who agrees to the improvements, sign an easement allowing the grade and bank stabilization work to be done on his or her property. After the work is completed, the property owner should maintain the stabilization measures (i.e. watering and inspection). Cost-sharing of the project between LARE, the homeowners association of Enchanted Hills, WACF, and the property owners themselves, will need to be discussed. There has been local discussion of cleaning or dredging the Enchanted Hills channels. If the cleaning or dredging were to steepen the slopes of the banks, it will affect their stability.

4.2.6 Estimated Cost of Construction

The probable cost of construction for the grade and bank stabilization measures is \$2,673,000 (Table 10) for the areas of severe erosion. To develop this cost, we used estimates from Lagoon Shoreline Restoration of the Chicago Botanic Garden (Harza, 1998), updated by Brown and Associates, Inc. November 2000. Costs estimates could vary widely with local contractors. For materials costs less than \$100,000, engineering fees were calculated at 15% of the materials cost. For materials costs above \$100,000 engineering fees were calculated at 10% of the materials cost. Services during construction were estimated at 10% of the materials cost. A 25% contingency was applied to the subtotal of materials, engineering, and services during construction. This estimate is based on 2001 dollars.

Table 10

COST ESTIMATE FOR GRADE AND BANK STABILIZATION MEASURES FOR THE ENCHANTED HILLS CHANNELS

Area	Treatment	Length (lineal feet)	Cost ($/lineal feet)	Total
ES5	Fiber Roll	382	$227	$ 86,700
ES8 and ES9	Herbaceous Vegetation	2,911	$192	$ 558,900
ES1, ES6, and ES13	Sheetpiling	1,816	$670	$1,216,700
ES11 and ES14	Boulders and Stone	199	$401	$ 79,800
Services During Construction and Engineering @ 10%				$ 195,000
Subtotal				$2,138,000
Contingency @ 25%				$ 535,000
Total				**$2,673,000**

Notes: Refer to Exhibit 11 for shoreline area locations.

4.2.7 Recommendation

The areas considered for grade and bank stabilization measures were identified as “severe” in Exhibit 11. We recommend fiber roll treatment for area ES5, herbaceous vegetation for ES8 and ES9, sheetpiling for areas ES1, ES6, and ES13, and boulders and stone for areas ES11 and ES14.

4.3 SEDIMENT TRAP/CONSTRUCTED WETLAND ON DILLON CREEK

4.3.1 Preliminary Design

The *Enchanted Hills Watershed Evaluation* (SWCD, 1994) suggested several methods to reduce sediment loadings on Dillon Creek, including grade control structures upstream and an enhanced wetland or sediment trap. Our site selection memorandum identified the area of DC2, where Dillon Creek crosses 1100 North Road (see Exhibit 13), as the location on which to investigate an enhanced wetland (Appendix A). As the biological integrity of DC1, DC2, and DC3 are similar, we recommended investigating the feasibility of a constructed wetland at DC2, due to the superior physical aspects of the site. The DC2 site is wide and flat, compared to sites DC1 and DC3, and is likely a source area for sediment. Placing a constructed wetland at DC2 would allow settling of sediment and stabilization of the area during storm flow, and straightforward access for maintenance. The DC2 site currently is a forested wetland and natural depositional area. Creating a structure to enhance the stormwater detention at DC2 will increase sedimentation at the site and protect downstream habitats.

We have identified two approaches to this problem area:

1. An enhanced wetland sheetpile structure that will have little or no maintenance requirements, but high costs, and;
2. An innovative, low cost alternative, a cable dam, that will require significant maintenance.

4.3.1.1 Enhanced Wetland

Wetlands, whether natural or created, are depressed areas that detain and store stormwater runoff and allow sedimentation and nutrient removal to take place. Objectives for the preliminary design of the enhanced wetland at this site include:

- Removal of a significant portion of the sediment generated from upstream lands during a 2-year 2-hour storm, and storms of lesser intensity;
- Compliance with Indiana dam safety regulations; and
- Adequate storm routing.

The enhanced wetland preliminary design was based on stilling basin guidelines (NIPC, 2000). Under these guidelines, a stilling basin is designed for velocity dissipation and for a 50 percent sediment removal rate. The recommended stilling basin volume is 500 cubic feet per impervious watershed acre, with an additional sediment storage capacity of 100 cubic feet per impervious watershed acre. The stilling basin should be at least three feet deep to prevent resuspension of settled particles by wind and turbulence, and the length of the sediment basin should be three times greater than the basin's width for greater settling capacity.

Our feasibility analysis is based upon a dam three feet high and 45 feet long, located approximately five feet upstream (south) of the culvert at 1100 North Road (Exhibit 14). The structure will contain a notch above the centerline of the channel to slowly release the water into the culvert. While there are many possibilities for the dam construction materials (concrete, sheetpile, earth, stone gabions, lumber), we recommend constructing the wall out of steel sheetpile, due to its simplicity of construction and relatively low cost.

4.3.1.2 Cable Dam

An alternative to the sheetpile structure is a novel wetland development technique currently being pioneered by Harza and some not-for-profit partners in Illinois. This method involves the construction of a cable dam (Exhibits 15-16), and mimics the floodway processes facilitated by beaver dams. While this is a relatively new technology and without a proven track record, its low cost makes it attractive. Cable dams require some time to fill up with debris before they are effective, and may create downstream scour. Therefore, should this option be implemented, we recommend armoring the downstream channel to reduce toe erosion.

4.3.2 Hydraulic and Hydrologic Analysis

A preliminary hydraulic and hydrologic analysis was performed to determine the potential for sediment control within the Dillon Creek watershed and compliance with the Indiana dam safety regulations and flood control. The headwaters of Dillon Creek are located in Noble County to the east, and the stream flows from the southeast to the northwest. The 1,027-acre drainage area upstream of site DC2 is largely agricultural (Exhibit 2). Land uses calculated from the Indiana GAP database are shown in Table 11.

Table 11

LAND USE IN DC2 WATERSHED
(Source: Indiana GAP Database)

Land Use	Acres
Urban	30
Agriculture	866
Wetlands	12
Forest/Woodland	119

Rainfall events are characterized by their recurrence interval, their intensity, and duration. Recurrence intervals area a statistic reflecting the average period of time expected between occurrences of that particular storm event when considering a long period of record. For example, a rainfall event with a 10-year recurrence interval has a 10% probability of being equaled or exceeded in any given year.

Peak storm flows were calculated from the above land uses and rainfall frequencies published by Huff and Angel (1992), using the Soil Conservation Service's TR-20 model (SCS, 1992) for watershed runoff. A sensitivity analysis on the TR-20 was performed (Exhibit 17), and the critical storm was found to be 3 hours in duration. Table 12 provides peak flow values for 3-hour storms at various recurrence intervals. The resulting hydrographs are included in Exhibit 18.

Table 12

PEAK STORM FLOWS AT DC2

Recurrence Interval (3-hour)	Peak Flow (cfs)
1-Year	93
2-Year	134
5-Year	208
10-Year	279
25-Year	400
50-Year	511
100-Year	748

Design criteria suggest a 2-year storm event for the preliminary design (NIPC, 2000). Indiana dam safety regulations for a structure draining more than a square mile (640 acres) require the spillway to be able to pass a 50-year storm. Structures will be required to be transparent to the regulatory flood, which in Indiana is the 100-year storm.

The HEC-RAS (Hydrologic Engineering Center's River Analysis System developed by the U.S. Army Corps of Engineers) program was used to perform a one-dimensional steady flow analysis of the stream conditions with the sediment trap at DC2. (Please see Appendix D for an overview of the model's capabilities.) Channel geometry at DC2 was approximated based on visual assessment during our site visit and USGS map 10-foot contours. The geometry of the existing culvert under 1100 North Road was obtained from the Kosciusko County Highway Department. The culvert is a 46-foot long steel squash pipe with a width of 6 feet, and a height of 3.75 feet. The culvert is situated 3.5 feet below the road surface, and has a slope of 0.5% over its length. Peak storm flows were obtained from Table 12, and the model was run for each storm event.

The HEC-RAS analysis indicates that the structure has little effect on the flood elevations at 1100 North Road under any of the flows in Table 12 (Exhibits 19-20). With the sheetpile dam, water surface elevations at 1100 North Road are increased by 0.01 feet (1-year 3-hour event) to 0.09 feet (100-year 3-hour event) over the existing conditions. Under all events analyzed, the sheetpile wall will overtop and allow the passage of the flow (Exhibit 21). The results show that the presence of the dam does not cause any significant changes to the current flood routing system.

While this level of analysis is acceptable for a feasibility analysis, a more detailed site conditions will need to be ascertained during final design and permitting. Site topographic and geotechnical surveys should be performed to more accurately characterize the shape of the channel and foundation conditions.

4.3.3 Lake Response

The sediment trapping efficiency of the enhanced wetland was calculated using the design geometry, channel velocity from the HEC-RAS output, and assumed sediment size distribution, sediment load, and settling velocities.

The sediment load was calculated using the EPA's Screening Procedure for Watershed Sediment Yield for the 2-year 24-hour design storm. This technique is based on rainfall, land uses, and soil types in the subwatershed (EPA 1985). The watershed sediment yield due to surface erosion is estimated as:

$$Y = s_d \sum_k X_k A_k \qquad \text{Equation (1)}$$

where

Y = annual sediment yield (tons/year)
X_k = erosion from source area k (tons/ha)
A_k = area of source are k (ha)
s_d = watershed sediment delivery ratio

The factor s_d accounts for the attenuation of sediment through deposition and filtering as it travels from source areas to the watershed outlet, in this case, the culvert under 1100 North Road.

Erosion from the DC2 watershed was estimated using the Universal Soil Loss Equation (USLE), which is an empirical equation designed to predict average annual soil loss from source areas (Equation 2).

$$X = 1.29(E)(K)(ls)(C)(P) \qquad \text{Equation (2)}$$

where

X = soil loss (tons/ha)
E = rainfall/runoff erosivity index (10^2 m-ton-cm/ha-hr)
K = soil erodibility (tons/ha per unit of E)
ls = topographic factor
C = cover/management factor
P = supporting practice factor

The erosivity term, E, is dependent upon rainfall data. Expected magnitudes of single-storm erosivity indices are presented in Wischmeier and Smith (1978). Erosivity values for the Dillon Creek watershed were interpolated between stations in South Bend and Fort Wayne, Indiana. For the 2-year storm, the erosivity is 64 (10^2 m-ton-cm/ha-hr) watershed. Soil erodibility, or "K" values, are a function of soil texture and organic content. Soil type was identified for the watershed using the STATSGO database. Corresponding K values are tabulated below.

Table 13

SOIL ERODIBILITY "K" VALUES AT DC2
(Source: STATSGO Database)

Soil Type	Soil ID	K Value
Kalamazoo	MI0007	0.22
Homer	IN0041	0.31
Wawasee	IN0149	0.28

The topographic factor, ls, is related to slope angle and slope length by the following relationship:

$$ls = (0.045x)^b (65.41 \sin^2\theta + 4.56 \sin\theta + 0.065) \qquad \text{Equation (3)}$$

where

x = slope length
b = exponent related to the slope (s)

and

b = 0.5 for s > 5%
b = 0.4 for 3.5% ≤ s ≤ 4.5%

$b = 0.3$ for $1 \le s \le 3$

$b = 0.2$ for $s \le 1$

The slope angle θ is obtained from the percent slope, s by:

$$\theta = \tan^{-1}(s/100) \qquad \text{Equation (4)}$$

Slopes of each soil type were taken from the STATSGO database (Table 14).

Table 14

TOPOGRAPHIC FACTORS FOR SOILS AT DC2
(Source: STATSGO Database)

Soil Type	**x**	**b**	**θ**	**ls**
KALAMAZOO	0-2	0.2	0.01	0.06
HOMER	0-2	0.2	0.01	0.06
WAWASEE	2-6	0.4	0.04	0.18

The cover/management C factor is a measure of the protection of the soil surface by plant canopy, crops, and mulches. The maximum C value is 1.0, which corresponds to no protection, while a value of 0.0 corresponds to total protection. Published C values were selected from Wischmeier and Smith (1978) based on the land use type (Table 15) for the fall season. No published values for urban lands are available. It was assumed that erosion is negligible from these sources as the area is most predominantly hardened and stabilized; therefore, the C value was set to 0.

Table 15

C VALUES FOR LAND USES IN WATERSHED
(Source: Wischmeier and Smith, 1978)

Land Use	**C Value**
Urban	0
Agriculture Row Crop	0.4
Agriculture Pasture/Grassland	0.26
Shrubland	0.055
Woodland	0.055
Forest Deciduous	0.004
Forest Evergreen	0.004
Forest Mixed	0.004
Wetland Forest	0.004
Wetland Woodland	0.055
Wetland Shrubland	0.055
Wetland Herbaceous	0.055
Wetland Sparsely Vegetated	0.055

The supporting practice factor P is a measure of the effect of traditional soil conservation practices on erosion from agricultural fields. Watershed-wide information on conservation practices would be difficult to obtain; therefore, P was assumed to be 1.0. This corresponds to no conservation practices, and serves as a "worst case" for the model. The 2-year storm event sediment yield for the DC2 watershed, calculated using Equation 1, is 69 tons of sediment.

Weighted distributions of sediment grain size (corresponding to the amount of surface area covered by the Wawasee and Kalamazoo soil types) were obtained (NRCS, 1998) used in the efficiency calculations (Exhibit 22). The sediment trap efficiency was estimated based on the velocity of the water upstream of the dam, and the settling capability of the sediment grain size at that velocity. We estimated sediment trap efficiency for the 2-year design storm to be 54% removal. The sediment trap efficiency is rather sensitive to grain size. The project at DC2 should approximately halve the mean annual sediment delivery to the Enchanted Hills channels.

4.3.4 Permit Requirements

Several different state and federal permits and approvals are required by the enhanced wetland project on Dillon Creek (Appendix B). The Indiana Department of Environmental Management requires a Section 401 Water Quality Certification (WQC) to conduct any activity that may result in a discharge into waters of the United States. In general, anyone who is required to obtain a permit from the U.S. Army Corps of Engineers (USACE) to engage in dredging, excavation, or filling activities must obtain a WQC. The followings are examples that would likely require a USACE permit and WQC: dredging a lake, river, stream, or wetland; filling a lake, river, stream, or wetland; bank stabilization; pond construction in wetlands; and roadway/bridge construction projects involving water crossings.

The Detroit USACE requires permits authorizing activities in, or affecting, navigable waters of the United States, the discharge of dredged fill material into waters of the United States, and the transportation of dredged material for the purpose of dumping into ocean waters. Waters of the U.S. also include adjacent wetlands and tributaries to navigable waters of the U.S. and other waters where the degradation or destruction of which could affect interstate or foreign commerce.

A Dam Safety Permit is required by the IDNR if the area of concern meets at least one of the following three requirements: watershed area of one square mile or greater, dam height of at least 20 feet, and a detention volume of 100 acre-feet or greater. A permit is required for areas draining greater than one square mile, under the Flood Control Act. Both these permits will be required as Dillon Creek has a drainage area of approximately 1.6 square miles.

4.3.5 Easements and Land Availability

Property owners of areas potentially affected by the sediment trap or constructed wetland on Dillon Creek were identified. Property owner information was obtained from the Property Boundary Plat Maps developed by the Department of Geographic Information Systems of Kosciusko County.

The sediment trap or constructed wetland on Dillon Creek would have the potential to impact one section of the 1100N Road easement and a land parcel, 007-093-002 owned by Nathaniel and Marilon Fick, 3520 S. Stafford St., Arlington, VA 22206.

4.3.6 Unusual Physical and/or Social Costs

During construction of the enhanced wetland or cable dam at DC2, it is possible that the existing forested wetland may be disturbed. The contract document can include requirements for preserving existing vegetation and replanting as necessary after the sheetpile or cable dam has been installed.

4.3.7 Bioassessments

Harza used standard environmental assessment tools to characterize the original three potential enhanced wetland sites on Dillon Creek. Physical habitat was evaluated utilizing the Ohio EPA's Qualitative Habitat Evaluation Index (OEPA 1989). The benthic community was characterized using the EPA's Rapid Bioassessment Protocol II (EPA 1999).

In the application of the QHEI, a 300-foot section of each site was inspected by a two-person field team. During the evaluation, habitat scores are recorded for seven physical habitat metrics and the results are summed. These qualitative parameters include: substrate, instream cover, channel morphology, riparian zone and bank erosion, pool and glide quality, riffle and run quality, and gradient. QHEI reflects the quality of stream physical habitat. In this procedure, the highest scores are assigned to the habitat parameters that have been shown to be correlated with streams having high biological diversity and biological integrity. Progressively lower scores are assigned to less desirable habitat features.

Tables 16 through 19 show the results of our habitat surveys. Discharge was measured using a marsh-McBirney flow meter. Water quality was measured using a Yellow Springs Data Sonde. Interestingly, the low dissolved oxygen concentrations at DC 2, which are below the state standard of 5 mg/L, are likely due to the low flows and natural organic loading conditions.

Table 16

DILLON CREEK STREAM DISCHARGES
SEPTEMBER 12, 2000

Site	Water body	Date	Discharge (ft^3/sec)
DC1	Dillon Creek	9/10/00	0.47
DC2	Dillon Creek	9/10/00	0.24
DC3	Dillon Creek	9/10/00	0.29

Table 17

DILLON CREEK IN-SITU WATER QUALITY RESULTS
SEPTEMBER 12, 2000

Site	Water	Temp (C)	Conductivity (umhos)	pH	DO (mg/L)
DC1	Dillon Creek	19.0	452	7.40	8.00
DC2	Dillon Creek	16.5	680	6.78	3.55
DC3	Dillon Creek	16.5	625	7.68	7.75

The QHEI results indicate that physical habitat quality at the three potential sites is similar. Riparian and channel habitat quality at DC2 was rated highest among the three sites, so we recommend minimal disruption of the area for construction. The substrate score at DC2 is the lowest as it is a natural depositional area.

Table 18

DILLON CREEK QUALITATIVE HABITAT EVALUATION INDEX

Site	Water body	Substrate	Cover	Channel	Riparian	Pool	Riffle	Gradient	QHEI
DC1	Dillon Creek	9	7	7	14	4	0	10	51
DC2	Dillon Creek	4	12	13	17	1	0	10	57
DC3	Dillon Creek	14	14	10	8	5	0	10	61

The US EPA's Rapid Bioassessment Protocol II (RBP II) utilizes the systematic field collection and analysis of major benthic taxa. This protocol is appropriate for prioritizing sites for watershed management projects. RBP II involves benthic analysis at the family taxonomic level. The technique utilizes field sorting and identification. The biological survey component of RBP II focuses on standardized sampling of benthic macroinvertebrates, supplemented by a cursory field observation of other aquatic biota such as periphyton, macrophytes, slimes and fish. The collection procedure provides representative samples of the macroinvertebrate fauna from riffle and run habitat types, and is supplemented with separate Course Particulate Organic Matter (CPOM) samples for the analysis of shredders and nonshredders. RBP II focuses on the riffle/run habitat because it is the most productive habitat available in stream systems and includes many pollution-sensitive taxa of the scraper and filtering collector functional feeding groups.

Collection of macroinvertebrates included quantitative and qualitative sampling methods. Quantitative sampling included triplicate sampling with a Surber sampler in riffles and runs. Qualitative sampling included rock picking for clinging individuals and netting individuals swimming within the water column. CPOM was collected from available detritus, leaves and sticks and individuals were counted until at least 50 individuals were obtained to evaluate the ratio of shredders to the total number of individuals collected.

Metrics used in the RBP indices evaluate aspects of elements and processes within the macroinvertebrate community. The indices do not incorporate metrics on individual condition, as is done with the fish-based Index of Biotic Integrity. The metrics in RBP II are taxa richness, Family Biotic Index, ratio of scrapers to filterers, ratio of EPT (Ephemeroptera, Plecoptera and Tricoptera) to Chironomidae, % contribution of dominant family, EPT index, ratio of shredders to nonshredders, and total individuals collected.

Table 19

DILLON CREEK MACROINVERTEBRATE RBP SCORES

Site	Taxa Richness	Family Biotic Index	Ratio of Scraper/ Filterer	Ratio of EPT/ Chironomidae	% Contribution Dominant Family	EPT Index	Ratio of Shredder/ Nonshredder	Total Number Collected
DC1	20	5.0	0.16	2.2	0.40	3	0.040	122
DC2	12	5.5	(45/0)	(3/0)	0.37	1	(0/50)	103
DC3	12	5.6	3.9	0.77	0.30	2	(0/50)	105

Taxa Richness is the total number of families present and represents biodiversity. Increasing diversity generally indicates with increasing health of the community and suggests that niche space, habitat, and food sources are adequate to support many species. This value generally increases with increasing water quality, habitat diversity and habitat suitability, and DC1 clearly has greater richness than the other two sites.

Modified Family Biotic Index (FBI) was developed to detect organic pollution and is a product of pollution tolerance values for family levels and the quantity of individuals within each family. Pollution tolerance values range from 0 to 10 for families and increase as water quality decreases. Again, the data suggest that the community present at DC1 is the least tolerant of pollution.

Feeding guilds of macroinvertebrates are enumerated in the RBP and used in two metrics. The ratio of the scrapers to filtering collectors reflects the riffle/run community food base. The relative abundance of scrapers and filtering collectors in the riffle/run habitat is indicative of periphyton community composition, availability of fine particulate organic material and the availability of attachment sites for filtering. Scrapers increase with an increase in diatom abundance and decrease in filamentous algae and aquatic mosses. Filamentous algae and aquatic mosses provide good attachment sites for filtering collectors and the organic enrichment often responsible for filamentous algae growth can also provide fine particulate organic material that is utilized by filtering collectors. Filtering collectors are also sensitive to toxicants bound to fine particles and should be the first group to decrease when exposed to steady sources of such bound toxicants. Dramatically differing scores in this metric were found between DC1 and DC2. No filters were found at DC2, but 45 scrapers were present.

The ratio of EPT (Ephemeroptera-mayflies, Plecoptera-stoneflies and Trichoptera-caddisflies) to Chironomidae (midges) are an indicator of good biotic condition if the sensitive groups (EPT's) demonstrate a substantial representation. If the Chironomidae have a disproportionately large number of individuals in comparison to the sensitive groups then environmental stress is indicated. Site DC3 had the poorest score in this category.

Percent Contribution of Dominant Family uses the abundance of the numerically dominant taxon relative to the total number of organisms as an indication of community balance at the family level. Scores in this category were similar for the three sites.

EPT Index value summarizes the taxa richness within the groups that are considered pollution sensitive and will generally increase with increasing water quality. This metric is the total number of distinct taxa within the groups Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies). Scores were fairly similar, with DC1 having 3 EPT, the highest score among the sites.

The ratio of the shredder functional feeding group relative to the abundance of all other functional feeding groups also allows for the evaluation of potential impairment. Shredders are sensitive to riparian zone impacts and are particularly good indicators of toxic effects when the toxicants involved are readily adsorbed to the CPOM and either affect microbial communities colonizing the CPOM or the shredders directly. Scores were similar among sites.

From the available data, it appears that site DC1 has the highest quality benthic community. DC1 has the richest fauna and the most pollution-sensitive species.

4.3.8 Probable Cost of Construction

The probable cost of construction for the sheetpile structure is $93,000 (Table 20). To develop this cost, we used estimates from Supporting Design Report for Wetland Development to Improve the Water Quality of Hamilton Lake (Harza, 1999), and adjusted by an inflation and safety factor of 10%. For materials costs less than $100,000, engineering fees were calculated at 15% of the materials cost. For materials costs above $100,000 engineering fees were calculated at 10% of the materials cost. Services during construction were estimated at 10% of the materials cost. A 25% contingency was applied to the subtotal of materials, engineering, and services during construction. This estimate is based on 2001 dollars. The stilling basin will be designed to hold 2-3 years worth of sediment, after which time maintenance costs will be incurred for sediment removal. The sediment trap will be designed to be drained completely for ease of cleanout. Annual inspection of the structure is also recommended. We estimate that maintenance costs will equal approximately 5% of the capital costs of construction.

Table 20

COST ESTIMATE FOR ENHANCED WETLAND AT DC2

Item	**Cost**	**Unit**	**Amount**	**Total**
Dewatering of Work Area	$ 5,500	lump sum	-	$ 5,500
Sediment Sampling and Testing	$ 1,650	sample	3	$ 5,000
Sheet Pile	$ 34	Square foot (installed)	601	$20,500
Excavation	$ 23	Square yard (small jobs)	42	$ 960
Rip Rap	$ 33	ton	83	$ 2,740
GeoTextile Fabric	$ 7	square yard	62	$ 400
Mobilization/Demobilization	$11,000	lump sum	-	$11,000
Clearing and Grubbing	$ 3,300	lump sum	-	$ 3,300
Restoration	$ 3,300	lump sum	-	$ 3,300
Surveying	$ 5,500	lump sum	-	$ 5,500
Services During Construction @ 10%				$ 6,000
Engineering @ 15%				$ 9,000
Subtotal				**$74,000**
Contingency @ 25%				$19,000
Total				**$93,000**

The cable dam is estimated to cost $4,000 (Table 21). To develop this cost, we used estimates from Materials costs based on estimate for Mundinger Creek, Illinois by Wetlands Initiative, and installation cost by hourly rate of R&C Fence of Fort Wayne, Indiana, and adjusted by an inflation and safety factor of 10%. A 30% contingency was applied to the subtotal of materials, engineering, and services during construction. This estimate is based on 2001 dollars. When the structure fills with sediment, it may be practical to build another cable dam further upstream or to clean out the original cable dam. Weekly inspection of the structure is also recommended.

Table 21

COST ESTIMATE FOR CABLE DAM

Item	**Cost**	**Unit**	**Amount**	**Total**
Cable clamps (1/2 inch)	$ 2.25	Clamp	4	$ 9
Cable clamps (3/4 inch)	$ 2.00	Clamp	2	$ 4
Cable (1/2 inch or 3/8 inch)	$ 0.77	Feet	34	$ 27
Chainlink fence (4 x 50 feet)	$35.00	Roll	3	$ 105
Reinforcing Bar Tie Wire	$ 4.00	Box	1	$ 4
J-Hooks (1/4 x 12 inches)	$ 1.25	Hook	24	$ 30
Soil Anchors (48 inch)	$13.00	Anchor	7	$ 91
Stanchions (2 inch x 4 feet gas pipe)	$20.00	Pipe	3	$ 60
Rip Rap	$33.00	Ton	30	$ 990
Installation	$60.00	Hours	24	$ 1440
Subtotal				**$3,000**
Contingency @ 30%				$1,000
Total				**$4,000**

4.3.9 Recommendation

We recommend implementing the enhanced wetland (sheetpile dam) at site DC2, due to its estimated efficiency of 54%, lower maintenance requirements than the cable dam, and its proven effectiveness as a treatment technology.

4.4 EROSION CONTROL ON DEVELOPMENT SITES AND SEDIMENT TRAP AND/OR STORMWATER RETENTION IN THE LEELAND ADDITION (MARTIN DITCH)

4.4.1 Preliminary Design

Martin Ditch, which collects stormwater runoff from surrounding agricultural areas, feeds into the channels, which then empty into Lake Wawasee. The fields near Martin Ditch are classed as highly erodible lands and were included in the United States Department of Agriculture's Conservation Reserve Program (CRP) at one time. The contract has since expired, and the fields have been tilled. Reestablishing these fields in the CRP program would reduce the amount of sediment entering channels at the Leeland Addition.

Our site selection memorandum (Harza, November 2000) identified the area just north of where Martin Ditch crosses South Drive in the Leeland Addition channel (see Exhibit 23), as one location for a sediment trap (Appendix E). Creating a structure to enhance the stormwater detention at this location will increase sedimentation at the site, and thereby protecting Lake Wawasee. A cable dam on Martin Ditch south of South Drive, and a series of check dams to control streambed erosion from Martin Ditch south of the road will be evaluated as well.

4.4.1.1 Erosion Control

Best management practices, or BMPs, are restrictions, structures or practices that mitigate the adverse anthropogenic effects on runoff quality and/or quantity. The Martin Ditch watershed is largely agricultural. There is a broad range of BMPs for agricultural lands. Appendix A discusses many of these. For the lands in the study area where corn and soybean production is the dominant use, some of the most effective BMPs include conservation tillage, conservation buffers and nutrient management.

4.4.1.1.1 Conservation Tillage

Conservation tillage, or crop residue management, involves leaving at least 30% of the ground covered with plant residue after planting. Varieties of conservation tillage include no-till/strip-till, ridge-till and mulch-till. Conservation tillage is widely practiced throughout Indiana and the Midwest. Conservation tillage improves water quality by reducing soil erosion and transport. It also improves soil quality by increasing organic content, moisture and nutrient retention capacity, and tilth

Table 22 contains data on tillage practices for various crops for three years. These data were exported from the TRANSECT Program administered by Purdue University, which was provided to Harza upon request. These data are specific to Kosciusko County rather than the Wawasee Area Watershed, but likely are a reasonable representation of regional trends in adopting conservation tillage. Total acreage in conservation tillage has increased dramatically in the last decade, from 20,000 acres in 1990 to over 97,000 acres in 1999, just under half of the tilled land.

The previous year's crop essentially controls the amount of tillage that can be performed while retaining 30% residue cover in the field. This may require crop rotation, as corn produces significant residue that can be left on the field, but soybeans do not.

All Indiana counties have extension agents available to provide technical assistance for implementing conservation tillage programs. In a 1997 nationwide survey of growers, the Natural Resource Conservation Service (NRCS) found that operation costs were rarely an impediment to implementing conservation tillage practices (cited in NRCS 1999). More common reasons stated in that survey were the expense of equipment changes and weed problems. As illustrated in Table 23, operating costs may be less under no-till systems than conventional tillage system. Costs for procuring the equipment however can be challenging for some operators.

Table 22

PRESENT CROP ACREAGE IN KOSCUISKO COUNTY BY TILLAGE SYSTEM
(Source: TRANSECT, Purdue University)

Tillage	Corn	Soybeans	Small grains	Forage	Idle	Other	Total
			1990				
Conventional	74,057	54,503	416	-	-	-	128,976
Mulch-till	3,328	2,912	3,328	-	416	-	9,984
No-till	6,657	7,489	416	-	1,248	-	9,810
Other	-	-	-	-	-	416	416
N/A	-	-	-	17,474	416	416	18,306
Unknown	-	416	18,306	-	10,817	-	29,539
Total	**84,042**	**65,320**	**22,466**	**17,474**	**12,897**	**832**	**203,031**
			1995				
Conventional	69,464	40,253	9,618	-	-	2,494	121,828
Mulch-till	3,206	2,850	-	-	-	-	6,056
No-till	11,043	30,635	356	-	356	-	42,391
Other	-	-	-	-	-	-	-
N/A	-	-	356	12,468	15,674	9,974	38,472
Unknown	-	-	-	-	-	-	-
Total	**83,713**	**73,738**	**10,330**	**12,468**	**16,030**	**12,468**	**208,747**
			1999				
Conventional	61,807	15,726	366	-	-	1,463	79,362
Mulch-till	10,240	19,383	366	-	-	366	30,355
No-till	15,360	44,618	5,852	-	-	731	66,562
Other	-	-	-	-	-	-	-
N/A	-	-	-	19,018	11,703	-	30,721
Unknown	-	-	-	-	-	-	-
Total	**87,407**	**79,727**	**6,584**	**19,018**	**11,703**	**2,560**	**206,999**

Table 23

OPERATING COSTS ($/acre) FOR CONVENTIONAL TILLAGE VERSUS NO-TILL (adapted from NRCS 1999)

Crops	Conventional Tillage	No-till System	Increase/decrease
Corn			
Operating/machinery	17	5	–12
Material	100	95	–5
Other	5	5	0
Total	122	105	-17
Soybeans			
Operating/machinery	14	6	–8
Material	55	83	28
Other	3	4	1
Total	72	93	21
Wheat			
Operating/machinery	12	6	–6
Material	38	49	11
Other	3	3	0
Total	53	58	5

4.4.1.1.2 Conservation Buffers

Conservation buffer strips of vegetation can, if properly planned and maintained, greatly reduce the runoff of soil and associated pollutants to nearby receiving waters. There are many practices that can be broadly grouped together as conservation buffers:

- Riparian buffers along streams
- Contour grass strips
- Field border buffers
- Filter strips
- Grassed swales and waterways
- Hedges or living snow fences
- Wetlands

- Other strategically planted vegetation that can intercept pollution or reduce wind or water erosion

Besides reducing sediment, nutrients and pesticides in runoff water, conservation buffers can greatly increase wildlife habitat. Filter strips should not be less than 20 feet, and protection of some resources may require much wider vegetation strips. Upgradient land slopes greater than 6% should have wider strips, possibly as wide as 130 feet. Floodplain riparian buffers having higher flows and longer duration flooding may need to be upwards of 200-feet wide.

The USDA's Conservation Reserve Program (CRP) is an excellent opportunity for establishing conservation buffers. Costs for installation of conservation buffers ranges widely, as expected given the broad variety of buffer types. The CRP shares in the cost of installation of conservation buffers and provides for long term contracts for the setting aside of eligible lands.

4.4.1.1.3 Nutrient Management

A crop nutrient management plan can increase the efficiency of crop fertilizer use while reducing nutrient losses to streams and lakes. Nutrient management reduces both production risk and environmental risk, and can increase agricultural profitability. Classically, nutrient management plans contain the following ten components:

1. Field Map (acreage, soils, water bodies and other sensitive habitats)
2. Soil Test (determining soil nutrient status)
3. Crop Rotation (sequencing of crops affects fertilizer needs)
4. Estimated Crop Yield
5. Sources and Forms of Nutrients (manure/sludge fertility analysis and understanding of inorganic fertilizers)
6. Sensitive Environmental/Social Areas
7. Recommended Rates of Nitrogen, Phosphorus & Potassium
8. Timing of Applications
9. Methods of Applications
10. Annual Review and Update

Again, all Indiana counties have extension agents available to provide technical assistance for developing nutrient management plans.

4.4.1.2 Sediment Trap North of South Drive at the Leeland Addition Channel

Sediment traps slow water flow and allow sedimentation and nutrient removal to take place. Objectives for the preliminary design of the sediment trap at this site include:

- Removal of a significant portion of the sediment generated from upstream lands during a 2-year 3-hour storm and storms of lesser intensity;
- Adequate storm routing.

The sediment trap preliminary design was based on stilling basin guidelines (NIPC, 2000). Under these guidelines, a stilling basin is designed for velocity dissipation and for a 50 percent sediment removal rate. The recommended stilling basin volume is 500 cubic feet per impervious watershed acre, with an additional sediment storage capacity of 100 cubic feet per impervious watershed acre. The stilling basin should be at least three feet deep to prevent resuspension of settled particles by wind and turbulence.

The basin will be created by a dam to the water surface in the current channel (Exhibit 14). The 45-foot long wall will be placed approximately sixty-five feet north of the culvert at South Drive (in the southwestern-most Leeland Addition channel) (Exhibit 23). This location was chosen as to minimize hazards to boat traffic near the structure, and to provide sufficient volume of settling of suspended solids. We recommend constructing the wall out of sheetpile due to its ease of construction and relatively low cost. This structure would serve to slow down the flow and allow sediment to settle out before entering the channels and the lake. This location facilitates easy access for construction and sediment removal.

4.4.1.3 Cable Dam

An alternative to the sheetpile structure in the Leeland Addition channel, is construction of a cable dam (as described in Section 4.3.1.2) south of South Drive on Martin Ditch. This method involves the construction of a cable dam (Exhibits 15-16). Cable dams require some time to fill up with debris before they start being effective, and may create downstream scour. Therefore, should this option be implemented, we recommend armoring the downstream channel to reduce toe erosion.

4.4.1.4 Check Dams on Martin Ditch Upstream of South Drive

The streambed of Martin Ditch has been identified as a possible source of sediment to the Leeland Addition channels and Lake Wawasee (NRCS, 1999). During storm events, erosive flow velocities scour the channel and add sediment to the flow. A series of check dams on Martin Ditch would reduce the energy and erosive capacity of the channel flow during rain events. Check dams across drainageways direct and concentrate flow into the center of the channel and protect vegetation in the early stages of growth. While they do collect sediment and act as filters, their main function is to reduce the flow velocity in the channel. Check dams can be comprised of stones, sandbags, or gravel (Exhibit 24).

Martin Ditch would require five check dams placed so that the toe of the upstream dam is at the same elevation as the top of the downstream dam. Specific dimensions of the dams will depend on site characteristics, however for this study they can be approximated as 2.75 feet high and the side slope of the dam will be 2:1 or flatter. The middle of the dam will be 9 inches lower than the outer edges at ground elevation to allow the water to flow over the center of the dam. Check dams are generally constructed of stone, and are extended 18 inches beyond the banks to prevent washouts. The downstream structure would be located six feet upstream of the culvert at South Drive, to provide for a stabilized outlet for the check dam series. The check dams should be inspected after each large storm, to ensure the stability and utility of the structures. Sediment should be removed when it accumulates to one half of the height of the dam.

4.4.2 Hydraulic and Hydrologic Analysis

A preliminary hydraulic and hydrologic analysis was performed to determine the potential for sediment control within the Martin Ditch watershed and to ensure compliance with the Indiana regulations and flood control. The headwaters of Martin Ditch are located in Kosciusko County to the west, and the stream flows from the south to the north. The 424-acre drainage area upstream of South Drive is largely agricultural (Exhibit 2). Land uses calculated from the Indiana GAP database are shown in Table 24.

Table 24

**LAND USE IN
MARTIN DITCH WATERSHED**

Land Use	Acres
Urban	11
Agriculture	311
Wetlands	4
Forest/Woodland	98

Peak storm flows were calculated from the above land uses and rainfall frequencies published by Huff and Angel (1992), using the Soil Conservation Service's TR-20 model (SCS, 1992) for watershed runoff. A sensitivity analysis on the TR-20 was performed (Exhibit 25), and the critical storm was found to be 3 hours in duration. Therefore, peak flow values for 3-hour storms at various recurrence intervals are reported below (Table 25), and the resulting hydrographs are included in Exhibit 26:

Table 25

**PEAK STORM FLOWS AT
MARTIN DITCH**

Recurrence Interval (3-hour)	Peak Flow (cfs)
1-Year	34
2-Year	50
5-Year	78
10-Year	105
25-Year	151
50-Year	194
100-Year	287

4.4.2.1 Sediment Trap North of South Drive at the Leeland Addition Channel

As per suggested design criteria used for stilling basins (NIPC, 2000), a 2-year storm event was used for the preliminary design. The area of drainage for the structure is 0.66 square miles, and therefore does not fall under Indiana dam safety regulation. Structures will be required to be transparent to the regulatory flood, which in Indiana is the 100-year storm.

The HEC-RAS program was used to perform a one-dimensional steady flow analysis of the stream conditions with the sediment trap at Leeland Addition. Channel geometry at Leeland Addition was approximated based on visual assessment during our site visit and USGS map 10-foot contours. The geometry of the existing culvert under South Drive was obtained from the Kosciusko County Highway Department. The culvert is a 45.5-foot long steel squash pipe with a width of 4.75 feet, and a height of 3.25 feet. The culvert is situated 3.75 feet below the road surface of South Drive, and has a slope of 2.7% over its length. Peak storm flows were obtained from Table 25, and the model was run for each storm event, including the 2-year design flow.

The HEC-RAS analysis indicates that the sediment trap structure has a slight effect on the flood elevations under all of the flows in Table 25. Under all events analyzed, the sheetpile will be overtopped (Exhibit 27). The results show that the presence of the dam causes flood elevations within the stilling basin (north of the culvert South Drive and south of the sheetpile dam) to rise by 0.6 feet (in the 100-year, 3-hour storm) to 2.5 feet (during the 1-year, 3-hour storm) above existing flood elevations (Exhibit 28). However, these increased flood elevations remain below the elevation of South Drive and the culvert invert. Therefore, the HEC-RAS analysis shows that the floodwater will not back up into the culvert nor back up over South Drive.

4.4.2.2 Check Dams

The HEC-RAS model was also used to determine the reduction in channel velocities due to the installation of the check dams. A series of five check dams was modeled in Martin Ditch so that the toe of the upstream dam is at the same elevation as the top of the downstream dam. The dams were placed between El. 886 and El. 876, as estimated from the USGS 10-foot contour quadrangle for Lake Wawasee, and over a 130-foot distance (Exhibits 23 and 29). The last structure will be placed six feet upstream of the culvert at

South Drive, to provide for a stabilized outlet for the check dam series. The dams are 2.75 feet high and the side slope of the dam will be 2:1 or flatter. The middle of the dam is 9 inches lower than the outer edges at ground elevation to allow the water to flow over the center of the dam (Exhibit 30). For the model, we assumed that the stone dams would remain in place under all flow conditions. In actually, the check dams will have to be inspected, and possibly maintained, after each storm event.

The results of the HEC-RAS model show that water surface elevations upstream of the check dams are increased by 1.5 feet (during the 100-year 3-hour storm event) to 2 feet (during the 1-year 3-hour storm event). However, during large storm events, it is likely that the dams will be displaced and will not significantly increase flood elevations upstream of the check dams. Elevations at the culvert at South Drive remain unchanged as a result of the check dams.

4.4.3 Lake Response

4.4.3.1 Sediment Trap North of South Drive at the Leeland Addition Channel

The sediment trapping efficiency was calculated using the assumed design geometry, channel velocity from the HEC-RAS output, assumed sediment size distribution, sediment load, and settling velocities.

Sediment loadings to Martin Ditch were estimating using the EPA's Screening Procedure for Watershed Sediment Yield for the 2-year design storm, as outlined in Section 4.3.3 and Equations (1) through (4). Input parameters are discussed below. The soil types underlying the Martin Ditch watershed are Crosier and Riddles (STATSGO database). Corresponding soil attributes are tabulated below.

Table 26

SOIL ERODIBILITY "K" VALUES IN MARTIN DITCH WATERSHED (Source: STATSGO Database)

Soil Type	Soil ID	K Value
Crosier	IN0019	0.32
Riddles	IN0015	0.32

Table 27

TOPOGRAPHIC FACTORS FOR SOILS IN MARTIN DITCH WATERSHED (Source: STATSGO Database)

Soil Type	**x**	**b**	**θ**	**ls**
Crosier	0-2	0.2	0.01	0.06
Riddles	0-2	0.2	0.01	0.06

The cover/management C factor is a measure of the protection of the soil surface by plant canopy, crops, and mulches. Table 15 displays the C values selected for each land use type. No published values for urban lands are available. It was assumed that erosion is negligible from these sources as the area is most predominantly hardened and stabilized; therefore, the C value was set to 0.

The supporting practice factor, P, is a measure of the effect of traditional soil conservation practices on erosion from agricultural fields. Watershed-wide information on conservation practices would be difficult to obtain; therefore, P was assumed to be 1.0. This corresponds to no conservation practices, and serves as a "worst case" for the model. The 2-year storm event sediment yield for the Martin Ditch watershed, calculated using Equation 1, is 10 tons of sediment.

Distributions of sediment grain size for the Crosier and Riddles soil types were obtained (NRCS, 1998) used in the efficiency calculations (Exhibit 31). The sediment trap efficiency was estimated based on the velocity of the water upstream of the dam, and the settling capability of the sediment grain size at that velocity. We estimated sediment trap efficiency for the 2-year design storm to be 35% removal. The sediment trap efficiency is rather sensitive to grain size. The project in the Leeland Addition channels should reduce the sediment delivery to the channels by approximately one-third.

4.4.3.2 Check Dams

HEC-RAS modeling results show that over the 130-foot distance where the check dams are placed, the velocities are reduced by approximately 68% for the 1-year 3-hour storm, 63% for the 2-year 3-hour storm, and 57% for the 5-year 3-hour storm. During the 10-, 25-, 50-, and 100-year storms, the effect of the check dams on velocity dissipation for large storm events is negligible and the dams are virtually transparent to the large flows.

4.4.4 Permit Requirements

Several different state and federal permits and approvals are required by the erosion control on development sites and sediment trap and check dams in the Leeland Addition and Martin Ditch (Appendix B). The Indiana Department of Natural Resources requires a joint permit application for construction within a floodway of a stream or river, navigable waterway, public fresh water lake, and ditch reconstruction. One of the permits listed under the joint permit application is the Lake Preservation Act. Lake Preservation Act states that no person may change the level of the water of shoreline of a public freshwater lake by excavating, filling in, or otherwise causing a change in the area or depth or affecting the natural resources scenic beauty or contour of the lake below the waterline or shoreline, without first securing the written approval of the DNR. A written permit from the department is also required for construction of permanent structures within the waterline or shoreline of a public freshwater lake. This permit would be applicable for the sediment trap in the Leeland Addition channel.

The Indiana Department of Environmental Management requires a Section 401 Water Quality Certification (WQC) to conduct any activity that may result in a discharge into waters of the United States. In general, anyone who is required to obtain a permit from the U.S. Army Corps of Engineers (USACE) to engage in dredging, excavation, or filling activities must obtain a WQC. The followings are examples that would likely require a USACE permit and WQC: dredging a lake, river, stream, or wetland; filling a lake, river, stream, or wetland; bank stabilization; pond construction in wetlands; and roadway/bridge construction projects involving water crossings. This permit would be applicable for the sediment trap in the Leeland Addition channel.

The Detroit USACE requires permits authorizing activities in, or affecting, navigable waters of the United States, the discharge of dredged fill material into waters of the United States, and the transportation of dredged material for the purpose of dumping into ocean waters. Waters of the U.S. also include adjacent wetlands and tributaries to navigable waters of the U.S. and other waters where the degradation or destruction of which could affect interstate or foreign commerce. This permit would be applicable for the sediment trap in the Leeland Addition channel.

4.4.5 Easements and Land Availability

Property owners of areas potentially affected by the erosion control on development sites and sediment trap and/or stormwater retention in the Leeland Addition/Martin Ditch subwatershed were identified. Property owner information was obtained from the Property Boundary Plat Maps developed by the Department of Geographic Information Systems of Kosciusko County.

The development in the Leeland Addition would have the potential to impact one section of the South Drive easement and the following land parcels: parcel 007-091-153 and 007-091-154 located on the south of South Drive, and owned by Rogers and Lucille J. Martin, 8289 E. South Rd., Syracuse, IN 46567; parcel 007-091-119A located on the north of South Drive by the channel, and owned by Michael P. and Karen S. Huey, 8058 E. South Rd., Syracuse, IN 46567; and parcel 007-091-120B located on the north of South Drive by the channel, and owned by Thomas K. Littlefield, 8076 E. Quiet Harbor Dr., Syracuse, IN 46567.

4.4.6 Unusual Physical and/or Social Costs

The check dams alternative on Martin Ditch would require inspection and possible maintenance after every significant rainfall. If not properly shaped and maintained, the check dams could wash down the streambed and end up entering the channel. The sheetpile sediment trap structure in the Leeland Addition channel will affect free navigation at the end of the channel, and buoys and warning signage will be necessary to alert boaters to its presence. Consent of the land owners at the end of the channel will need to be obtained before this option could be implemented.

4.4.7 Forested Wetland Characterization

Harza reconnoitered the forested wetland east of 800 East Road at Leeland Addition. Dominant species are tabulated below (Table 28). All species found were common, and characteristic of wetlands; no endangered, threatened or rare species were found. Obligate wetland species, facultative wetland species, and facultative upland species were found in both areas.

Table 28

LEELAND ADDITION/MARTIN DITCH DOMINANT VEGETATION SPECIES

Common Name	**Latin Name**	**Wetland Indicator Category**
Green Ash	*Fraxinus pennsylvanica*	FACW
Spotted Touch-Me-Not	*Impatiens capensis*	FACW
American Elm	*Ulmus americana*	FACW-
Eastern Cottonwood	*Populus deltoides*	FAC+
American Beech	*Fagus grandifolia*	FACU
Shagbark Hickory	*Carya ovata*	FACU
Scrub Oak	*Quercus ilicifolia*	NA

Key: OBL = obligate wetland species; probability of occurrence in wetlands: > 99%
FACW = facultative wetland species; probability of occurrence in wetlands: 34 to 66%
FACW+ = facultative wetland species; probability of occurrence in wetlands: 51 to 66%
FACW- = facultative wetland species; probability of occurrence in wetlands: 34 to 50%
FACU = facultative upland species; probability of occurrence in wetlands: 1 to 33%
FACU+ = facultative upland species; probability of occurrence in wetlands: 17 to 33%
FACU- = facultative upland species; probability of occurrence in wetlands: 1 to 16%
UPL = upland species; probability of occurrence in wetlands: <1%

4.4.8 Estimated Cost of Construction

4.4.8.1 Erosion Control Plan

Recent NRCS guides have estimated consulting for preparation of nutrient management plans at $5/acre (NRCS 1999). Based upon this unit rate and adjusting for inflation, plan development for Leeland Addition subwatershed will cost approximately $2,000.

4.4.8.2 Sediment Trap North of South Drive at the Leeland Addition Channel

The probable cost of construction for the sheetpile structure is $74,300 (Table 29). To develop this cost, we used estimates from Supporting Design Report for Wetland Development to Improve the Water Quality of Hamilton Lake (Harza, 1999), and adjusted by an inflation and safety factor of 10%. For materials costs less than $100,000, engineering fees were calculated at 15% of the materials cost. For materials costs above $100,000 engineering fees were calculated at 10% of the materials cost. Services during construction were estimated at 10% of the materials cost. A 25% contingency was applied to the subtotal of materials, engineering, and services during construction. This estimate is based on 2001 dollars. The stilling basin will be designed to hold 2-5 years worth of sediment, after which time maintenance costs will be incurred for sediment removal. Annual inspection of the structure is also recommended. We estimate that maintenance costs will be approximately 5% of the capital cost of construction.

Table 29

COST ESTIMATE FOR SEDIMENT TRAP IN LEELAND ADDITION CHANNEL

Item	Cost	Unit	Amount	Total
Sediment Sampling and Testing	$ 1,650	sample	3	$ 5,000
Sheet Pile	$ 34	Square foot (installed)	596	$20,300
Mobilization/Demobilization	$11,000	lump sum	-	$11,000
Restoration	$ 3,300	lump sum	-	$ 3,300
Surveying	$ 5,500	lump sum	-	$ 5,500
Construction Inspection/Administration @ 10%				$ 5,000
Engineering @ 15%				$ 7,000
Subtotal				**$58,000**
Contingency @ 25%				$15,000
Total				**$73,000**

4.4.8.3 Cable Dam

As outlined in Section 4.3.7, the cable dam is estimated to cost $4,000 (Table 21). When the structure fills with sediment, it may be practical to build another cable dam further upstream or to clean out the original cable dam. Annual inspection of the structure is also recommended.

4.4.8.4 Check Dams on Martin Ditch

The probable cost of construction for the five checkdams is $29,000 (Table 30). To develop this cost, we used estimates from Supporting Design Report for Wetland Development to Improve the Water Quality of Hamilton Lake (Harza, 1999), and adjusted by an inflation and safety factor of 10%. For materials costs less than $100,000, engineering fees were calculated at 15% of the materials cost. For materials costs above $100,000 engineering fees were calculated at 10% of the materials cost. Services during construction were estimated at 10% of the materials cost. A 25% contingency was applied to the subtotal of materials, engineering, and services during construction. This estimate is based on 2001 dollars. The check dams should be inspected and maintained after each significant rainfall event. We estimate that maintenance costs will be approximately 10% of the capital cost of construction.

Table 30

COST ESTIMATE FOR CHECK DAMS ON MARTIN DITCH

Item	**Cost**	**Unit**	**Amount**	**Total**
Rip Rap	$ 33	ton	30	$ 1,000
Mobilization/Demobilization	$ 4,900	lump sum	-	$ 4,900
Clearing and Grubbing	$ 3,300	lump sum	-	$ 3,300
Restoration	$ 3,300	lump sum	-	$ 3,300
Surveying	$ 5,500	lump sum	-	$ 5,500
Services During Construction @ 10%				$ 2,000
Engineering @ 15%				$ 3,000
Subtotal				**$23,000**
Contingency @ 25%				$ 6,000
Total				**$29,000**

4.4.9 Recommendation

We recommend installing the check dams on Martin Ditch, due to their cost and estimated velocity reduction of up to 68%. We also recommend creating an erosion control plan for the Leeland Addition watershed.

4.5 EROSION CONTROL ON DEVELOPMENT SITES AND SEDIMENT TRAP AND/OR STORMWATER RETENTION IN THE SOUTH SHORE SUBWATERSHED

4.5.1 Preliminary Design

Our site selection memorandum (Harza, November 2000) identified several improvement projects relating to nutrient and sediment runoff from the South Shore golf course (Appendix E). Projects identified for full engineering feasibility evaluation are:

1. Source control at the golf course;
2. A sediment trap east of Rte 13 (as to avoid disturbing the existing wetland west of Rte 13), and;
3. Biorentention technology at the South Shore Country Club parking lot.

4.5.1.1 Nutrient Management Plan for Golf Course

Best Management Practices (BMPs) are actions or methods that could be used to maintain the best quality golf course in the most efficient manner and with little risk to the environment. BMPs minimize inputs of fertilizers, pesticides and labor while achieving a desired level of course performance and quality. The following provides a discussion of some of the BMPs applicable to the protection and maintenance of the golf course ecosystem.

The maintenance department of a golf course is responsible for irrigation, mowing, fertilization, pesticide application and general upkeep of the golf course grounds. The maintenance area is likely where pesticides are loaded into application equipment, mowers and other pieces of equipment are serviced, and pesticides, fuel, fertilizer, and cleaning solvents are stored. This is where pollution of soil, surface water, or ground water is most likely to occur. Contamination can occur when pesticides are spilled, containers or equipment cleaned and the rinsewater dumped on the ground or discharged into surface water, or improperly cleaned containers are stockpiled or buried. Proper management of the maintenance area is an important part of responsible chemical and pesticide use. Some of the BMPs for a golf course maintenance area include: storing the contaminants of similar type in covered, lockable storage areas, handling them over impermeable surfaces, cleaning up spills promptly and properly, and recycling the materials where possible. An up-to-date inventory of pesticides and their Material Safety Data Sheets should also be prepared and be accessible at all times.

Fertilizer management programs can help to create a soil environment where sufficient nutrients are available for optimal plant health with minimal risk to water quality. Nitrogen and phosphorous are the nutrients most likely to affect water quality. Carefully planned applications are critical to the health of turfgrasses and the environment. Quick-release fertilizers should not be applied before a heavy rainfall or irrigation. In addition, fertilizers must not be applied directly into lakes, drainage areas, and other water bodies. A buffer zone of low-maintenance grasses or natural vegetation between areas of highly maintained turf and water can help to trap unwanted nutrients and to prevent erosion. When practical, grass clippings should be allowed to remain on the turf area to decompose and recycle nutrients back into the turf.

Maintaining the appropriate level of irrigation is important not only to the turf, but to the preservation of water quality. A properly designed and installed irrigation system will apply a uniform level of water at the desired rate and time, and will only provide enough water to compensate for that lost by evapotranspiration. The irrigation system should be shut off if runoff is observed, and only re-activated after the water infiltrates the soil. Too much water may leach contaminants into the groundwater or carry them as runoff to surface water.

4.5.1.2 Sediment Trap at South Shore Ditch East of Route 13

Sediment traps slow water flow and allow sedimentation and nutrient removal to take place. Objectives for the preliminary design of the sediment trap at this site include:

- Removal of a significant portion of the sediment generated from upstream lands during a 2-year 3-hour storm and storms of lesser intensity;
- Adequate storm routing.

The sediment trap preliminary design was based on stilling basin guidelines (NIPC, 2000). Under these guidelines, a stilling basin is designed for velocity dissipation and for a 50 percent sediment removal rate. The recommended stilling basin volume is 500 cubic feet per impervious watershed acre, with an additional sediment storage capacity of 100 cubic feet per impervious watershed acre. The stilling basin should be at least three feet deep to prevent resuspension of settled particles by wind and turbulence. The length of the sediment basin was designed to be three times greater than the basin's width for greater settling capacity.

The basin will be created by a dam approximately three feet high within the current stream channel. The 20-foot long dam will be placed approximately 125 feet east of Route 13 and ten feet west of South Shore Drive on the South Shore Ditch (Exhibit 32). The structure will contain a notch above the centerline of the channel to release the water slowly into the culvert (Exhibit 14). While there are many possibilities for materials (concrete, sheetpile, earth, lumber), we generally recommend sheetpile due to its ease of construction and relatively low cost. This structure would serve to slow down the flow and allow sediment to settle out before entering the lake. Locating the sediment trap in this location would disturb some forest cover, however would facilitate easy access for construction and sediment removal from South Shore Drive. A water line running from Lake Wawasee west to the golf course through South Shore Ditch will either need to be relocated around the sediment trap, or included in the final design of the sheetpile wall.

4.5.1.3 Bioretention at the South Shore Country Club Parking Lot

Bioretention is an alternative to conventional BMPs. As shown in Exhibit 33, the bioretention system is a shallow depression that retains stormwater on site and uses plant and layers of soil, sand and mulch to treat and manage the amount of nutrients and other pollutants in stormwater runoff. It is applicable to impervious surfaces at commercial, residential and industrial areas. Typically, bioretention facilities are placed to intercept runoff near the source. Runoff from an impervious area is either diverted directly into the bioretention area or conveyed into the system by a curb and gutter collection system. Native shrubs, grasses and small trees are planted in the depression to promote evapotranspiration, maintain soil porosity, encourage biological activity, and promote uptake of some pollutants when water gradually infiltrates the system. An underdrain system is included to collect the infiltrated water and discharge it to a downstream sewer system.

Design details for bioretention structures are found elsewhere (PGDER, 1993). For preliminary design purposes, this manual suggests the following:

- The size of a bioretention area should be 5 to 7 percent of the drainage area multiplied by the rational method runoff coefficient determined for the site.
- The recommended minimum dimensions are 15 feet wide by 40 feet long. Any facilities wider than 20 feet should be twice as long as they are wide.
- The maximum recommended ponding depth is 6 inches.
- Planting soils should be sandy loam, loamy sand, or loam texture with a clay content ranging from 10 to 25 percent.
- Three species of both trees and shrubs are recommended to be planted at a rate of 1000 trees and shrubs per acre. The shrub-to-tree ratio should be 2:1 to 3:1. On average, trees and shrubs should be spaced 12 feet and 8 feet apart, respectively.

The proposed bioretention facility will be located on between the golf course pavilion and Route 13. This drainage area of 82,500 square feet (including the clubhouse, storage buildings, and the parking lot of the golf course) is outside the watershed delineated for South Shore Ditch, and it drains east to Lake Wawasee through an underdrain. The bioretention facility will treat this drainage area of the parking lot and clubhouse areas, and the runoff coefficient used was 0.85, corresponding to a high percentage of impervious surfaces. The required size of the facility is estimated to be 4,900 square feet. Therefore, a preliminary layout involves a 45-foot wide by 110-foot long bioretention system, with a maximum ponding depth of six inches.

4.5.2 Hydraulic and Hydrologic Analysis

A preliminary hydraulic and hydrologic analysis was performed to determine the potential for sediment control within the South Shore watershed and to ensure compliance with the Indiana regulations and flood control. The headwaters of South Shore Ditch are located in Kosciusko County to the west, and the stream flows from the southeast to the northeast. The drainage area upstream of South Shore Drive is largely agricultural (Exhibit 2). Land uses calculated from the Indiana GAP database are shown in Table 31.

Table 31

LAND USE IN
SOUTH SHORE WATERSHED
Source: Indiana GAP Database

Land Use	Acres
Urban	4
Agriculture	512
Wetland	5
Forest/Woodland	55

Peak storm flows were calculated from the above land uses and rainfall frequencies published by Huff and Angel (1992), using the Soil Conservation Service's TR-20 model (SCS, 1992) for watershed runoff. A sensitivity analysis on the TR-20 was performed (Exhibit 34), and the critical storm was found to be 2 hours in duration. Therefore, peak flow values for 2-hour storms at various recurrence intervals are reported below (Table 32), and the resulting hydrographs are included in Exhibit 35:

Table 32

PEAK STORM FLOWS AT
SOUTH SHORE DITCH

Recurrence Interval (2-hour)	Flow (cfs)
1-Year	73
2-Year	106
5-Year	167
10-Year	225
25-Year	326
50-Year	420
100-Year	529

4.5.2.1 Sediment Trap at South Shore Ditch East of Route 13

As per suggested design criteria used for stilling basins, a 2-year storm event was used for the preliminary design. The area of drainage for the structure is 0.9 square miles, and therefore does not fall under Indiana dam safety restrictions. Structures will be required to be transparent to the regulatory flood, which in Indiana is the 100-year storm.

The HEC-RAS (Hydrologic Engineering Center's River Analysis System developed by the U.S. Army Corps of Engineers) was used to perform a one-dimensional steady flow analysis of the stream conditions with the sediment trap at South Shore Ditch. Please see Appendix D for an overview of the model's capabilities.

Channel geometry at South Shore Ditch was approximated based on visual assessment during our site visit and USGS map 10-foot contours. The geometry of the existing 3-sided box culvert under South Drive was obtained from the Kosciusko County Highway Department. The culvert is a 26-foot long 3-sided box culvert with a width of 13 feet, and a maximum height of 4.33 feet. The culvert is situated 1.25 feet below the road surface of South Drive, and has a slope of 1.0% over its length. Peak storm flows were obtained from Table 32, and the model was run for each storm event, including the 2-year design flow.

The HEC-RAS analysis indicates that the structure has a slight effect on the flood elevations under all of the flows in Table 32. Under all events analyzed, the sheetpile wall will overtop and allow the passage of the flow (Exhibit 36). The results show that the presence of the dam causes flood elevations south of the culvert at South Shore Drive and south of the culvert at Route 13 to rise by 0.01 feet (in the 100-year, 2-hour storm) to 2.1 feet (during the 1-year, 2-hour storm) above existing flood elevations (Exhibit 37). However, these increased flood elevations remain below the elevation of South Shore Drive and of Route 13. Therefore, the HEC-RAS analysis shows that the floodwater will not back up over South Shore Drive or Route 13.

This level of analysis is acceptable for a preliminary feasibility analysis, however a more detailed basin model will need to be developed during final design and permitting. Site elevation surveys should be performed in the upcoming phases to more accurately characterize the shape of the channel.

4.5.3 Lake Response

4.5.3.1 Sediment Trap at South Shore Ditch East of Route 13

The efficiency of the sediment trap was calculated using the design geometry, channel velocity from the HEC-RAS output, sediment size distribution, sediment load, and settling velocities.

Sediment loadings to South Shore Ditch were estimating using the EPA's Screening Procedure for Watershed Sediment Yield for the 2-year design storm, as outlined in Section 4.3.3 and Equations (1) through (4). Input parameters are discussed below. The soil types underlying the South Shore Ditch watershed are Crosier and Riddles (STATSGO database). Corresponding soil attributes are tabulated in Tables 26 and 27 in Section 4.4.3.1.

The cover/management C factor is a measure of the protection of the soil surface by plant canopy, crops, and mulches. Table 15 displays the C values selected for each land use type. No published values for urban lands are available. It was assumed that erosion is negligible from these sources as the area is most predominantly hardened and stabilized; therefore, the C value was set to 0.

The supporting practice factor P is a measure of the effect of traditional soil conservation practices on erosion from agricultural fields. Watershed-wide information on conservation practices would be difficult to obtain; therefore, P was assumed to be 1.0. This corresponds to no conservation practices, and serves as a "worst case" for the model. The 2-year storm event sediment yield for the South Shore Ditch watershed, calculated using Equation 1, is 5 tons of sediment.

Distributions of sediment size for the Crosier and Riddles soil types was obtained (NRCS, 1998) used in the efficiency calculations (Exhibit 31). The sediment trap efficiency was estimated based on the velocity of the water upstream of the dam, and the settling capability of the sediment grain size at that velocity. Estimated sediment trap efficiency for the 2-year design storm was 27% removal. The sediment trap efficiency is sensitive to grain size, therefore it is recommended that sediment size be more accurately characterized as part of the final design.

4.5.3.2 Bioretention at the South Shore Country Club Parking Lot

Bioretention removes storm water pollutants in many ways, including adsorption, filtration, plant uptake, microbial activity, decomposition, sedimentation and volatilization. These processes depend on adequate contact time with the soil and vegetation, and therefore the performance of the biofilter is dependent upon the design filtration rates. It is estimated that a bioretention facility designed within the recommended filtration rates will remove 90% of total suspended solids and 70-80% of phosphorus and nitrogen compounds (PGDER, 1993).

4.5.4 Permit Requirements

Several different state and federal permits and approvals are required by the erosion control on development sites and sediment trap and/or stormwater retention project in the South Shore subwatershed (Appendix B). The Indiana Department of Environmental Management requires a Section 401 Water Quality Certification (WQC) to conduct any activity that may result in a discharge into waters of the United States. In general, anyone who is required to obtain a permit from the U.S. Army Corps of Engineers (USACE) to engage in dredging, excavation, or filling activities must obtain a WQC. The followings are examples that would likely require a USACE permit and WQC: dredging a lake, river, stream, or wetland; filling a lake, river, stream, or wetland; bank stabilization; pond construction in wetlands; and roadway/bridge construction projects involving water crossings.

The Detroit USACE requires permits authorizing activities in, or affecting, navigable waters of the United States, the discharge of dredged fill material into waters of the United States, and the transportation of dredged material for the purpose of dumping into ocean waters. Waters of the U.S. also include adjacent wetlands and tributaries to navigable waters of the U.S. and other waters where the degradation or destruction of which could affect interstate or foreign commerce.

4.5.5 Easements and Land Availability

Property owners of areas potentially affected by the erosion control on development sites and sediment trap and/or stormwater retention in the South Shore subwatershed were identified. Property owner information was obtained from the Property Boundary Plat

Maps developed by the Department of Geographic Information Systems of Kosciusko County.

The nutrient management plan and bioretention technology in the South Shore subwatershed would have the potential to the following land parcels: parcels 007-086-97, 007-086-99, 007-086-100, 007-086-101, 007-086-103, 007-086-104, 007-086-105, and 007-087-001 located on the west of Route 13, and owned by South Shore Country Club LLC, 10601 N. SR13, Syracuse, IN 46567. The sediment trap in the South Shore watershed would have the potential to impact one section of the Route 13 easement and the following land parcels: parcel 007-086-094A located on the east of Route 13, and owned by Mildred J. Folds, 10896 N. South Shore Dr., Syracuse, IN 46567; and parcel 007-086-094B located on the east of Route 13, and owned by Paul and Linda Phillabaum, 10918 N. South Shore, Syracuse, IN 46567.

4.5.6 Unusual Physical and/or Social Costs

Both the nutrient management plan and the bioretention alternative depend on the South Shore Golf Course for acceptance and implementation. The construction of the sediment trap may disturb forest cover at South Shore Drive. In addition, this alternative may impact the golf course's water line that runs under the box culvert at South Shore Drive. Should this option be recommended, and depending on final design, permission may be necessary to alter the existing location of the water line.

4.5.7 Wetland Characterization

Harza reconnoitered two wetland communities at South Shore. These sites were east and west of Hwy 13. Dominant species were identified and are tabulated below. All species found were common; no endangered, threatened or rare species were found. Obligate wetland species, facultative wetland species, and facultative upland species were found. We characterize both wetlands as forested wetlands.

Table 33 SOUTH SHORE WETLAND DOMINANT SPECIES		
SOUTH SHORE WETLAND WEST OF SOUTH SHORE DRIVE		
Common Name	**Latin Name**	**Wetland Indicator Category**
Silver Maple	Acer saccharinum	FACW
Box-Elder	*Acer negundo*	FACW-
Red Mulberry	*Morus rubra*	FAC-
GOLF COURSE WETLAND WEST OF ROUTE 13		
Common Name	**Latin Name**	**Wetland Indicator Category**
Spotted Touch-Me-Not	Impatiens capensis	FACW
American Sycamore	*Platanus occidentalis*	FACW
Eastern Cottonwood	*Populus deltoides*	FAC+
Common Pokeweed	*Phytolacca americana*	FAC-
Black Walnut	*Juglans nigra*	FACU

Key:
OBL = obligate wetland species; probability of occurrence in wetlands: > 99%
FACW = facultative wetland species; probability of occurrence in wetlands: 34 to 66%
FACW+ = facultative wetland species; probability of occurrence in wetlands: 51 to 66%
FACW- = facultative wetland species; probability of occurrence in wetlands: 34 to 50%
FACU = facultative upland species; probability of occurrence in wetlands: 1 to 33%
FACU+ = facultative upland species; probability of occurrence in wetlands: 17 to 33%
FACU- = facultative upland species; probability of occurrence in wetlands: 1 to 16%
UPL = upland species; probability of occurrence in wetlands: <1%

4.5.8 Estimated Cost of Construction

4.5.8.1 Nutrient Management Plan for the Golf Course

Recent NRCS guides have estimated consulting for preparation of nutrient management plans at $5/acre (NRCS 1999). According to the Kosciusko County's property boundary information, the South Shore Country Club's lands total approximately 115 acres. Based upon this unit rate and adjusting for inflation, plan development for South Shore golf course will cost approximately $2,000.

4.5.8.2 Sediment Trap at South Shore Ditch East of Route 13

The probable cost of construction for the sediment trap is $72,000 (Table 34). To develop this cost, we used estimates from Supporting Design Report for Wetland Development to Improve the Water Quality of Hamilton Lake (Harza, 1999), and adjusted by an inflation and safety factor of 10%. For materials costs less than $100,000, engineering fees were calculated at 15% of the materials cost. For materials costs above $100,000 engineering fees were calculated at 10% of the materials cost. Services during construction were estimated at 10% of the materials cost. A 25% contingency was applied to the subtotal of materials, engineering, and services during construction. This estimate is based on 2001 dollars. The stilling basin will be designed to hold 3-5 years worth of sediment, after which time maintenance costs will be incurred for sediment removal. Annual inspection of the structure is also recommended. We estimate that maintenance costs will be approximately 5% of the capital cost of construction.

Table 34

COST ESTIMATE FOR SEDIMENT TRAP AT SOUTH SHORE DITCH

Item	Cost	Unit	Amount	Total
Dewatering of Work Area	$ 5,500	Lump sum	-	$ 5,500
Sediment Sampling and Testing	$ 1,650	Sample	3	$ 5,000
Sheet Pile	$ 34	Square foot (installed)	265	$ 9,050
Excavation	$ 23	Square yard (small jobs)	27	$ 630
Rip Rap	$ 33	Ton	37	$ 1,200
GeoTextile Fabric	$ 7	Square yard	27	$ 180
Mobilization/Demobilization	$11,000	Lump sum	-	$11,000
Clearing and Grubbing	$ 3,300	Lump sum	-	$ 3,300
Restoration	$ 3,300	Lump sum	-	$ 3,300
Surveying	$ 5,500	Lump sum	-	$ 5,500
Services During Construction @ 10%				$ 5,000
Engineering @ 15%				$ 7,000
Subtotal				**$57,000**
Contingency @ 25%				$15,000
Total				**$72,000**

4.5.8.3 Bioretention at the South Shore Country Club Parking Lot

The probable cost of construction for the bioretention facility is $179,000 (Table 35). To develop this cost, we used estimates from Prince George's County, Maryland (PGDER, 1993) and Supporting Design Report for Wetland Development to Improve the Water Quality of Hamilton Lake (Harza, 1999), and adjusted by an inflation and safety factor of 10%. For materials costs less than $100,000, engineering fees were calculated at 15% of the materials cost. For materials costs above $100,000 engineering fees were calculated at 10% of the materials cost. Services during construction were estimated at 10% of the materials cost. A 25% contingency was applied to the subtotal of materials, engineering, and services during construction. This estimate is based on 2001 dollars. Annual inspection, pruning and weeding, and replacement of the plantings as required, are also recommended. We estimate the operation and maintenance cost at 10% of the capital cost.

Table 35

COST ESTIMATE FOR BIORETENTION FACILITY

Item	**Cost**	**Unit**	**Qty**	**Total**
Mobilization/Demobilization	$ 8,400	Lump sum	-	$ 8,400
Surveying	$ 5,500	Lump sum	-	$ 5,500
Clearing and Grubbing	$ 3,300	Lump sum	-	$ 3,300
Planting and Grading	$ 20	Square foot (installed)	4,900	$ 98,000
Restoration	$ 3,300	Lump sum	-	$ 3,300
Services During Construction @ 10%				$ 12,000
Engineering @ 10%				$ 12,000
Subtotal				**$143,000**
Contingency @ 25%				$ 36,000
Total				**$179,000**

4.5.9 Recommendation

We recommend preparing a nutrient management plan for the golf course, and installing a bioretention facility east of the golf course parking lot. These two choices will address both the area of the golf course that drains north to South Shore Ditch, and the area that drains east to the lake via an underdrain.

4.6 RECONSTRUCTED WETLAND IN THE BAYSHORE SWAMP

4.6.1 Preliminary Design

Our site selection memorandum identified alternative improvement projects relating to nutrient and sediment runoff from the Bayshore watershed (Appendix E). Projects identified for feasibility evaluation are:

1. Enhancing the wetland west of CR 850E, which will back up the water and allow settling of sediment without the loss of the recreational benefits of the ponds, and;
2. The in-channel sediment trap at Bayshore north of Hatchery Road, which would provide sediment removal while allowing easy access for maintenance and sediment removal.

Objectives for this site are:

- Removal of a significant portion of the sediment generated from upstream lands during a 2-year 3-hour storm and storms of lesser intensity, and
- Adequate storm routing.

4.6.1.1 Enhanced Wetland West of CR 850E

Wetlands may slow water flow and allow sedimentation and nutrient removal to take place. The preliminary design allows for velocity dissipation and for a 50 percent sediment removal rate (NIPC, 2000). The wetland will be enhanced by extending a sheetpile dam four feet above the bottom of the current culvert under CR 850E. The 20-foot long wall will be placed approximately 20 feet west of CR 850E and 500 feet south of Hatchery Road in the Bayshore existing wetland (Exhibit 38). The structure will contain a notch above the centerline of the channel to release the water slowly over the wall and into the culvert (Exhibit 14). Placing the sediment trap off the CR 850E road would facilitate easy access for construction equipment and sediment removal. Some existing wetland vegetation may be disturbed during construction of the sheetpile dam.

4.6.1.2 Sediment Trap in Bayshore Channel

Sediment traps also slow water flow and allow sedimentation and nutrient removal to take place. The sediment trap preliminary design was also designed for velocity dissipation and for a 50 percent sediment removal rate (NIPC, 2000). The sediment trap will be created by a wall extending four feet above the bottom of the current channel. The 45-foot long wall will be placed approximately 35 feet north of Hatchery Road in the westernmost Bayshore Channel (Exhibit 38). The structure will contain a notch above the centerline of the channel to release the water slowly over the wall and into the culvert (Exhibit 14). We recommend constructing the wall out of sheetpile due to its ease of construction and relatively low cost. Placing the sediment trap in this location may inhibit navigation in the southernmost end of the channel, however this location would facilitate easy access for construction and sediment removal from Hatchery Road.

4.6.2 Hydraulic and Hydrologic Analysis

A preliminary hydraulic and hydrologic analysis was performed to determine the effects of these two alternatives on sediment reduction and to ensure compliance with Indiana regulations. The drainage area upstream of the Bayshore wetland and channel is 108 acres and largely agricultural (Exhibit 2). Land uses calculated from the Indiana GAP database are shown in Table 36.

Table 36

LAND USE IN
BAYSHORE WATERSHED
Source: Indiana GAP Database

Land Use	Acres
Urban	2
Agriculture	77
Wetlands	5
Forest/Woodland	24

Peak storm flows were calculated for watershed runoff using the Soil Conservation Service's TR-20 model (SCS, 1992). A sensitivity analysis on the TR-20 was performed for both the area upstream of the Bayshore wetland, and the area upstream of the

Bayshore channel (Exhibits 39 and 41). The critical storm was found to be 2 hours in duration for both sites. Therefore, peak flow values for 2-hour storms at various recurrence intervals are reported below (Tables 37 and 38), and the resulting hydrographs are included in Exhibits 40 and 42.

Table 37

PEAK STORM FLOWS AT BAYSHORE WETLAND

Recurrence Interval (2-hour)	Flow (cfs)
1-Year	12
2-Year	19
5-Year	32
10-Year	44
25-Year	66
50-Year	87
100-Year	112

Table 38

PEAK STORM FLOWS AT BAYSHORE CHANNEL

Recurrence Interval (2-hour)	Flow (cfs)
1-Year	13
2-Year	20
5-Year	33
10-Year	46
25-Year	69
50-Year	91
100-Year	116

4.6.2.1 Enhanced Wetland West of CR 850E

As per suggested design criteria used for stilling basins, a 2-year storm event was used for the preliminary design. The area of drainage for the structure is 0.14 square miles, and therefore does not fall under Indiana dam safety restrictions. Structures will be required to be transparent to the regulatory flood, which in Indiana is the 100-year storm.

The HEC-RAS model was used to perform a one-dimensional steady flow analysis of the stream conditions with the sediment trap at the Bayshore wetland. Channel geometry at the Bayshore wetland was approximated based on a visual assessment performed during our site visit, and USGS map 10-foot contours. The culverts at CR 850 E and Hatchery Road have diameters too small to be included in the Kosciusko County Highway Department's database at the present time, and therefore assumptions were made regarding the geometry of these culverts. We assumed that the culvert under CR 850 E is a 30-foot long 18-inch pipe, and that the culvert under Hatchery Road emptying into the Bayshore channel is a 280-foot long 24-inch pipe. Peak storm flows were obtained from Table 37, and the model was run for each storm event, including the 2-year design flow.

The HEC-RAS analysis indicates that the structure has an insignificant effect on the flood elevations under all of the flows in Table 37. Under all events analyzed, the sheetpile wall will overtop and allow the passage of the flow (Exhibit 43). The results show that the presence of the dam does not affect flood elevations (Exhibit 44), nor does the dam change the water velocities at this location. According to the model results, water flows over CR 850 E during all but the 1-year 2-hour storm, and flood elevations are controlled by the size of the culverts under CR 850 E Road and under Hatchery Road. All storms analyzed for the existing conditions cause ponding west of CR 850 E Road, and model results show that placing a sheetpile dam at this location will not increase retention time enough to improve the trapping efficiency of the existing wetland. Therefore, this alternative will not alter sediment loadings to Lake Wawasee and is not recommended for further study.

4.6.2.2 Sediment Trap in Bayshore Channel

As per suggested design criteria used for stilling basins (NIPC, 2000), a 2-year storm event was used for the preliminary design. The area of drainage for the structure is 0.17 square miles, and therefore does not fall under Indiana dam safety restrictions.

The HEC-RAS model was also used to perform a one-dimensional steady flow analysis of the stream conditions with the sediment trap at the Bayshore channel. Channel geometry at the Bayshore channel was approximated based on a visual assessment performed during our site visit, and USGS map 10-foot contours. We assumed that the culvert under CR 850 E is a 30-foot long 18-inch pipe, and that the culvert under Hatchery Road emptying into the Bayshore channel is a 280-foot long 24-inch pipe. These assumptions will need to be field-verified during final design. Peak storm flows were obtained from Table 38, and the model was run for each storm event, including the 2-year design flow.

The HEC-RAS analysis indicates that the structure has a minor effect on the flood elevations under all of the flows in Table 38. Under all events analyzed, the sheetpile will overtop and allow the passage of the flow (Exhibit 45). The results show that the presence of the proposed dam causes flood elevations north of the culvert at Hatchery Road and south of the sheetpile dam to rise by 0.29 feet (in the 100-year, 2-hour storm) to 2.33 feet (during the 1-year, 2-hour storm) above existing flood elevations (Exhibit 46). However, these increased flood elevations remain below the elevation of Hatchery Road.

This level of analysis is acceptable for a preliminary feasibility analysis, however a more detailed basin model will need to be developed during final design and permitting. Site elevation surveys should be performed in the upcoming phases to more accurately characterize the shape of the channel.

4.6.3 Lake Response

4.6.3.1 Enhanced Wetland West of CR 850E

The efficiency of the enhanced wetland was calculated using the design geometry, estimated channel velocity from the HEC-RAS output, assumed sediment size distribution, estimated sediment load, and settling velocities.

Sediment loadings to the Bayshore wetland were estimated using the EPA's Screening Procedure for Watershed Sediment Yield for the 2-year design storm, as outlined in Section 4.3.3 and Equations (1) through (4). Input parameters are discussed below. The soil type underlying the Bayshore wetland watershed is Crosier (STATSGO database). Corresponding soil attributes are tabulated in Tables 26 and 27 in Section 4.4.3.1.

The cover/management C factor is a measure of the protection of the soil surface by plant canopy, crops, and mulches. Table 15 displays the C values selected for each land use type. No published values for urban lands are available. It was assumed that erosion is negligible from these sources as the area is most predominantly hardened and stabilized; therefore, the C value was set to 0.

The supporting practice factor P is a measure of the effect of traditional soil conservation practices on erosion from agricultural fields. Watershed-wide information on conservation practices would be difficult to obtain; therefore, P was assumed to be 1.0. This corresponds to no conservation practices, and serves as a "worst case" for the model. The 2-year storm event sediment yield for the Bayshore wetland watershed, calculated using Equation 1, is 3 tons of sediment.

Distributions of sediment size for the Crosier soil type was obtained (NRCS, 1998) used in the efficiency calculations (Exhibit 31). The sediment trap efficiency was estimated based on the velocity of the water upstream of the dam, and the settling capability of the sediment grain size at that velocity. It was estimated that the existing Bayshore Wetland's efficiency for the 2-year design storm was 42% removal. The sheetpile structure at CR 850 E would not change this trapping existing efficiency. The sediment trap efficiency is sensitive to grain size, therefore it is recommended that sediment size be more accurately characterized as part of the final design.

4.6.3.2 Sediment Trap in Bayshore Channel

The efficiency of the sediment trap was calculated using the design geometry, estimated channel velocity from the HEC-RAS output, assumed sediment size distribution, estimated sediment load, and settling velocities.

Sediment loadings to the Bayshore channel were again estimated using the EPA's Screening Procedure for Watershed Sediment Yield for the 2-year design storm, as outlined in Section 4.3.3 and Equations (1) through (4). Input parameters are discussed below. The soil type underlying the Bayshore wetland watershed is Crosier (STATSGO database). Corresponding soil attributes are tabulated in Tables 26 and 27 in Section 4.4.3.1.

The cover/management C factor is a measure of the protection of the soil surface by plant canopy, crops, and mulches. Table 15 displays the C values selected for each land use type. No published values for urban lands are available. It was assumed that erosion is negligible from these sources as the area is most predominantly hardened and stabilized; therefore, the C value was set to 0. This assumption is acceptable for our purposes here.

The supporting practice factor P is a measure of the effect of traditional soil conservation practices on erosion from agricultural fields. Watershed-wide information on conservation practices would be difficult to obtain; therefore, P was assumed to be 1.0. This corresponds to no conservation practices, and serves as a "worst case" for the model. The 2-year storm event sediment yield for the Bayshore channel watershed, calculated using Equation 1, is 3 tons of sediment.

Distributions of sediment size for the Crosier soil type was obtained (NRCS, 1998) used in the efficiency calculations (Exhibit 31). The sediment trap efficiency was estimated based on the velocity of the water upstream of the dam, and the settling capability of the sediment grain size at that velocity. Estimated sediment trap efficiency for the 2-year design storm was 45% removal. The sediment trap efficiency is sensitive to grain size, therefore it is recommended that sediment size be more accurately characterized as part of the final design.

4.6.4 Permit Requirements

Several different state and federal permits and approvals are required by the reconstructed wetland project in the Bayshore swamp (Appendix B). The Indiana Department of Natural Resources requires a joint permit application for construction within a floodway of a stream or river, navigable waterway, public fresh water lake, and ditch reconstruction. One of the permits listed under the joint permit application is the Lake Preservation Act. Lake Preservation Act states that no person may change the level of the water of shoreline of a public freshwater lake by excavating, filling in, or otherwise causing a change in the area or depth or affecting the natural resources scenic beauty or contour of the lake below the waterline or shoreline, without first securing the written approval of the DNR. A written permit from the department is also required for construction of permanent structures within the waterline or shoreline of a public freshwater lake. This permit would be required for the sediment trap in the Bayshore Channel.

The Indiana Department of Environmental Management requires a Section 401 Water Quality Certification (WQC) to conduct any activity that may result in a discharge into waters of the United States. In general, anyone who is required to obtain a permit from the U.S. Army Corps of Engineers (USACE) to engage in dredging, excavation, or filling activities must obtain a WQC. The followings are examples that would likely require a USACE permit and WQC: dredging a lake, river, stream, or wetland; filling a lake, river, stream, or wetland; bank stabilization; pond construction in wetlands; and roadway/bridge construction projects involving water crossings. Should any excavation be necessary of the wetland site, approval may be required under the Ditch Act.

The Detroit USACE requires permits authorizing activities in, or affecting, navigable waters of the United States, the discharge of dredged fill material into waters of the United States, and the transportation of dredged material for the purpose of dumping into ocean waters. Waters of the U.S. also include adjacent wetlands and tributaries to navigable waters of the U.S. and other waters where the degradation or destruction of which could affect interstate or foreign commerce.

4.6.5 Easements and Land Availability

Property owners of areas potentially affected by the reconstructed wetland in the Bayshore Swamp were identified. Property owner information was obtained from the Property Boundary Plat Maps developed by the Department of Geographic Information Systems of Kosciusko County.

The development in the Bayshore Swamp would have the potential to impact one section of the Hatchery Road easement and the following land parcels: parcel 007-101-091A located on the south of Hatchery Road by 850E Road, and owned by Jerry C. and Seritakay Lowe, 8746 E. Hatchery Rd., Syracuse, IN 46567; parcel 007-101-076 also located on the south of Hatchery Road by 850E Road, and owned by Gary Mithing, 9702 N. Bayshore Dr., Syracuse, IN 46567; parcel 007-102-001 located on the south of Hatchery Road by 850E Road, and owned by Rev. Ethel B. Hite, 8423 E. Hatchery Rd., Syracuse, IN 46567; parcels 007-102-001D and 007-102-100C also located on the south of Hatchery Road by 850E Road, and owned by Donald M. and Louise McClintic, 12 Green Acre Ct. Brownsburg, IN 46112; parcel 007-101-164 owned by Milett Kedys and Janet Brouwer, 3043 Rose Brook Circle, Westchester, IL 60154; and parcel 007-101-094 owned by Fred and Roberta Kujawski, 506 Magnolia Dr., Crown Pt., IN 46307.

4.6.6 Unusual Physical and/or Social Costs

The sheetpile sediment trap structure in the Bayshore channel could have navigational impacts, therefore buoys and warning signage will be necessary to alert boaters to its presence.

4.6.7 Wetland Characterization

Harza reconnoitered vegetation communities in the Bayshore area south of Hatchery Road and both east and west of CR 850 E. Dominant species were identified in two wetland areas, on the east and west sides of Road 850 East. Wetland vegetation species are tabulated below. All species found were common; no endangered, threatened or rare species were found. Obligate wetland species, facultative wetland species, and facultative upland species were found in both areas. We characterize the Bayshore wetlands are a mosaic of emergent, scrub-shrub and forested wetlands. The wetlands and well positioned to capture soil eroded from upland areas.

Table 39

BAYSHORE WETLANDS

WETLANDS EAST OF CR 850 E

Common Name	**Latin Name**	**Wetland Indicator Category**
Broad-Leaved Arrowhead	*Sagittaria latifolia*	OBL aquatic – emergent
Narrow-Leaf Cattail	*Typha angustifolia*	OBL
Sandbar Willow	*Salix exigua*	OBL
Spotted Touch-Me-Not	*Impatiens capensis*	FACW
Red-Osier Dogwood	*Cornus stolonifera*	FACW
American Elm	*Ulmus americana*	FACW-
Eastern Cottonwood	*Populus deltoides*	FAC+
Black Walnut	*Juglans nigra*	FACU
Multiflora Rose	*Rosa multiflora*	FACU
Bristly Gooseberry	*Ribes setosum*	NA
Staghorn Sumac	*Rhus typhina*	NA

WETLANDS WEST OF CR 850 E

Common Name	**Latin Name**	**Wetland Indicator Category**
Broad-Leaved Arrowhead	*Sagittaria latifolia*	OBL aquatic - emergent
Narrow-Leaf Cattail	*Typha angustifolia*	OBL
Sandbar Willow	*Salix exigua*	OBL
Black Willow	*Salix nigra*	OBL
Spotted Touch-Me-Not	*Impatiens capensis*	FACW
Silver Maple	*Acer saccharinum*	FACW
Red-Osier Dogwood	*Cornus stolonifera*	FACW
Eastern Cottonwood	*Populus deltoides*	FAC+
Staghorn Sumac	*Rhus typhina*	NA

Key:
OBL = obligate wetland species; probability of occurrence in wetlands: > 99%
FACW = facultative wetland species; probability of occurrence in wetlands: 34 to 66%
FACW+ = facultative wetland species; probability of occurrence in wetlands: 51 to 66%
FACW- = facultative wetland species; probability of occurrence in wetlands: 34 to 50%
FACU = facultative upland species; probability of occurrence in wetlands: 1 to 33%
FACU+ = facultative upland species; probability of occurrence in wetlands: 17 to 33%
FACU- = facultative upland species; probability of occurrence in wetlands: 1 to 16%
UPL = upland species; probability of occurrence in wetlands: <1%

4.6.8 Estimated Cost of Construction

4.6.8.1 Enhanced Wetland West of CR 850E

The probable cost of construction for the enhanced wetland is $72,000 (Table 40). To develop this cost, we used estimates from Supporting Design Report for Wetland Development to Improve the Water Quality of Hamilton Lake (Harza, 1999), and adjusted by an inflation and safety factor of 10%. For materials costs less than $100,000, engineering fees were calculated at 15% of the materials cost. For materials costs above $100,000 engineering fees were calculated at 10% of the materials cost. Services during construction were estimated at 10% of the materials cost. A 25% contingency was applied to the subtotal of materials, engineering, and services during construction. This estimate is based on 2001 dollars. The stilling basin will be designed to hold 3-5 years worth of sediment, after which time maintenance costs will be incurred for sediment removal. Annual inspection of the structure is also recommended. We estimate that maintenance costs will be approximately 5% of the capital cost of construction.

Table 40

COST ESTIMATE FOR ENHANCED WETLAND WEST OF CR 850E

Item	Cost	Unit	Amount	Total
Dewatering of Work Area	$ 5,500	lump sum	-	$ 5,500
Sediment Sampling and Testing	$ 1,650	sample	3	$ 5,000
Sheet Pile	$ 34	Square foot (installed)	265	$ 9,100
Excavation	$ 23	Square yard (small jobs)	27	$ 600
Rip Rap	$ 33	ton	37	$ 1,200
GeoTextile Fabric	$ 7	square yard	27	$ 200
Mobilization/Demobilization	$11,000	lump sum	-	$11,000
Clearing and Grubbing	$ 3,300	lump sum	-	$ 3,300
Restoration	$ 3,300	lump sum	-	$ 3,300
Surveying	$ 5,500	lump sum	-	$ 5,500
Services During Construction @ 10%				$ 5,000
Engineering @ 15%				$ 7,000
Subtotal				**$57,000**
Contingency @ 25%				$15,000
Total				**$72,000**

4.6.8.2 Sediment Trap in Bayshore Channel

The probable cost of construction for the sediment trap is $69,000 (Table 41). To develop this cost, we used estimates from Supporting Design Report for Wetland Development to Improve the Water Quality of Hamilton Lake (Harza, 1999), and adjusted by an inflation and safety factor of 10%. For materials costs less than $100,000, engineering fees were calculated at 15% of the materials cost. For materials costs above $100,000 engineering fees were calculated at 10% of the materials cost. Services during construction were estimated at 10% of the materials cost. A 25% contingency was applied to the subtotal of materials, engineering, and services during construction. This estimate is based on 2001 dollars. The stilling basin will be designed to hold 3-5 years worth of sediment, after which time maintenance costs will be incurred for sediment removal. Annual inspection of the structure is also recommended. We estimate that maintenance costs will be approximately 5% of the capital cost of construction.

Table 41

COST ESTIMATE FOR SEDIMENT TRAP IN BAYSHORE CHANNEL

Item	**Cost**	**Unit**	**Amount**	**Total**
Sediment Sampling and Testing	$ 1,650	Sample	3	$ 5,000
Sheet Pile	$ 34	Square foot (installed)	530	$18,000
Mobilization/Demobilization	$11,000	lump sum	-	$11,000
Restoration	$ 3,300	lump sum	-	$ 3,300
Surveying	$ 5,500	lump sum	-	$ 5,500
Services During Construction @ 10%				$ 5,000
Engineering @ 15%				$ 7,000
Subtotal				**$55,000**
Contingency @ 25%				$14,000
Total				**$69,000**

4.6.9 Recommendation

We recommend the sediment trap in the Bayshore channel, due to its lower cost and its estimated trapping efficiency of 45%.

5.0 ACTION PLAN AND SCHEDULE

The following lake protection strategies are proposed for implementation at Lake Wawasee.

1. Restore Dillon Creek flow to Johnson Bay via a lock and dam structure in the Enchanted Hills channels and a culvert connecting the channels to the wetland under East Wawasee Drive.

2. Stabilize and revegetate shorelines in Enchanted Hills through:

    - Fiber rolls
    - Herbaceous Vegetation
    - Sheetpiling
    - Boulders and Stone

3. Increase sediment trapping on Dillon Creek at site DC2 (at 1100 North Road) via an enhanced wetland (sheetpile dam).

4. Reduce source sediment by creating an erosion control plan for the Leeland Addition watershed.

5. Reduce flow velocities and erosion of the streambed on Martin Ditch by installing five check dams along the creek.

6. Reduce source nutrients by creating a nutrient management plan for the South Shore golf course.

7. Reduce nutrients and sediment from the golf course parking lot and clubhouse facilities via filtration through a bioretention facility east of the South Shore County Club parking lot.

8. Increase sediment trapping at the Bayshore watershed by installing a sediment trap in the Bayshore channels.

The estimated costs for the recommended lake protection techniques are outlined below. The project components have been described in previous sections of this feasibility study. The approach outlined in Table 42 is recommended for state and/or federal cost-sharing as part of a design and implementation project. Engineering fees and contingencies are included in the costs below.

Table 42

BUDGET FOR DESIGN AND IMPLEMENTATION PROJECTS

Treatment Type	Section	Construction	Services	Engineering	Contingency	Total
Restore Dillon Creek Flow to Johnson Bay Via Lock and Dam	4.1	$133,000	$14,000	$14,000	$41,000	$202,000
Enchanted Hills Grade and Bank Stabilization	4.2	$1,943,000	-	$195,000	$535,000	$2,673,000
Enhanced Wetland on Dillon Creek at DC2	4.3	$59,000	$6,000	$9,000	$19,000	$93,000
Erosion Control Plan for Martin Ditch Watershed	4.4	-	-	$1,800	$200	$2,000
Five Check Dams on Martin Ditch	4.4	$18,000	$2,000	$3,000	$6,000	$29,000
Nutrient Management Plan for South Shore Golf Course	4.5	-	-	$1,800	$200	$2,000
Bioretention for South Shore Country Club Parking Lot	4.5	$119,000	$12,000	$12,000	$36,000	$179,000
Sediment Trap in Bayshore Channel	4.6	$43,000	$5,000	$7,000	$14,000	$69,000
Total		**$2,315,000**	**$39,000**	**$243,600**	**$651,400**	**$3,249,000**

We recognize that funds may not be available for immediate design and implementation of all of these recommended projects. Therefore, we recommend that the following five projects be designed and implemented during 2001-2002: Enhanced Wetland on Dillon Creek at DC2, Erosion Control Plan for Martin Ditch Watershed, Five Check Dams on Martin Ditch, Nutrient Management Plan for the South Shore Golf Course, and a Sediment Trap in the Bayshore Channel. We recommended designing and implementing the remaining projects at a later date. The schedule is designed to reflect this two-tiered approach.

Table 43

PROPOSED SCHEDULE FOR DESIGN AND IMPLEMENTATION PROJECTS

Activity	**2001**				**2002**				**2003**				**2004**			
Quarter:	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Restore Dillon Creek Flow to Johnson Bay Via Lock and Dam											D	D	D		x	
Enchanted Hills Grade and Bank Stabilization											D	D			x	
Enhanced Wetland on Dillon Creek at DC2			D	D	D		x									
Erosion Control Plan for Leeland Addition Watershed					D	D										
Five Check Dams on Martin Ditch					D		x									
Nutrient Management Plan for South Shore Golf Course					D	D										
Bioretention for South Shore Country Club Parking Lot											D	D	D		x	
Sediment Trap in Bayshore Channel			D	D	D		x									

D = Design Phase

X = Construction

REFERENCES

Commonwealth Biomonitoring. *Lake Enhancement Diagnostic/Feasibility Study for the Wawasee Area Watershed*, sponsored by the Wawasee Area Conservancy Foundation, and the IDNR Division of Soil Conservation LARE Program, 1995.

Harza Engineering Company (Harza). Lake Wawasee Engineering Feasibility Study, Identification of Potential Pollution Control Projects, November 2000.

Harza Engineering Company (Harza). Lagoon Shoreline Restoration Master Plan for the Chicago Botanic Garden, January 1998. Revised cost estimates by Brown and Associates, Inc. November 2000.

Harza Engineering Company (Harza). Supporting Design Report for Wetland Development to Improve the Water Quality of Hamilton Lake, September 1999.

Hill, Ross A., Hudson, Holly, Clark, Jay J., Gray, Theodore R., and Kirschner, Robert. *Clean Lakes Program Phase 1 Diagnostic-Feasibility Study of Herrick Lake*, DuPage County, Illinois, Forest Preserve District of DuPage County, March 1994.

Hippensteel, Peter. *Preliminary Investigation of the Lakes of Kosciusko County*, funded by Kosciusko Lake Preservation and Development Council and the IDNR's LARE Program, March 1989.

Huff, Floyd A. and James R. Angel. *Rainfall Frequency Atlas of the Midwest*. Illinois State Water Survey, Champaign, Bulletin 71, 1992.

Indiana GAP Database, Land Cover GIS themes.

Kosciusko County Highway Department, *Small Structure Inspection Report Culvert No. C-214*, June 25, 1998.

Kosciusko County Soil and Water Conservation District and Noble County Soil and Water Conservation District (SWCD). *Enchanted Hills Watershed Evaluation,* in cooperation with IDNR, Division of Soil Conservation, Natural Resource Conservation Service, the Kosciusko County Surveyor, and the Noble County Surveyor, 1994.

Natural Resources Conservation Service (NRCS). Letter from Samuel St. Clair to Betty Knapp regarding Bayshore Addition, 1998.

Natural Resources Conservation Service (NRCS). Letter from Samuel St. Clair to Bob Myers regarding Leeland Addition/Martin Ditch 1999.

Natural Resources Conservation Service (NRCS). 1999. *CORE4 Conservation Practices Training Guide. The Common Sense Approach to Natural Resource Conservation*. USDA NRCS, August, 1999.

Northeastern Illinois Planning Commission (NIPC). *Urban Stormwater Best Management Practices for Northeastern Illinois: A Course Notebook*. May 2000.

Prince George's County Department of Environmental Resources (PGDER), 1993. *Design Manual for Use of Bioretention in Storm Water Management*. Division of Environmental Management, Watershed Protection Branch. Landover, Maryland.

Purdue University, Department of Agronomy Indiana Climate Archives, 2000. http://shadow.agry.purdue.edu/sc.index.html

Spacie, A. and Loeb, S.L. *Long-term Trends in Trophic State of Indiana Lakes (USA) Following Phosphorus Reduction*. Verh. Internat. Verein. Limnol. 24:464-469, 1990, as cited in: Commonwealth Biomonitoring. *Lake Enhancement Diagnostic/Feasibility Study for the Wawasee Area Watershed*, sponsored by the Wawasee Area Conservancy Foundation, and the IDNR Division of Soil Conservation LARE Program, 1995.

Schueler, T.R.,Controlling Urban Runoff: *A Practical Manual for Planning and Designing Urban BMPs*. Publication no. 87703. Metropolitan Washington Council of Governments, 1987. 275pp.

Schueler, T.R., P.A. Kumble, and M.A. Heraty, 1992. *A Current Assessment of Urban Best Management Practices: Techniques for Reducing Non-Point Source Pollution In the Coastal Zone*. Publication no. 92705. Metropolitan Washington Council of Governments. Washington, DC. 127pp.

U.S. Army Corps of Engineers, Hydrologic Engineering Center. *HEC-RAS River Analysis System User's Manual Version 2.2*. September 1998.

U.S. Environmental Protection Agency (EPA). *Water Quality Assessment: A*

Screening Procedure for Toxic and Conventional Pollutants in Surface and Groundwater – Part 1. EPA600-6-85-002a, 1985.

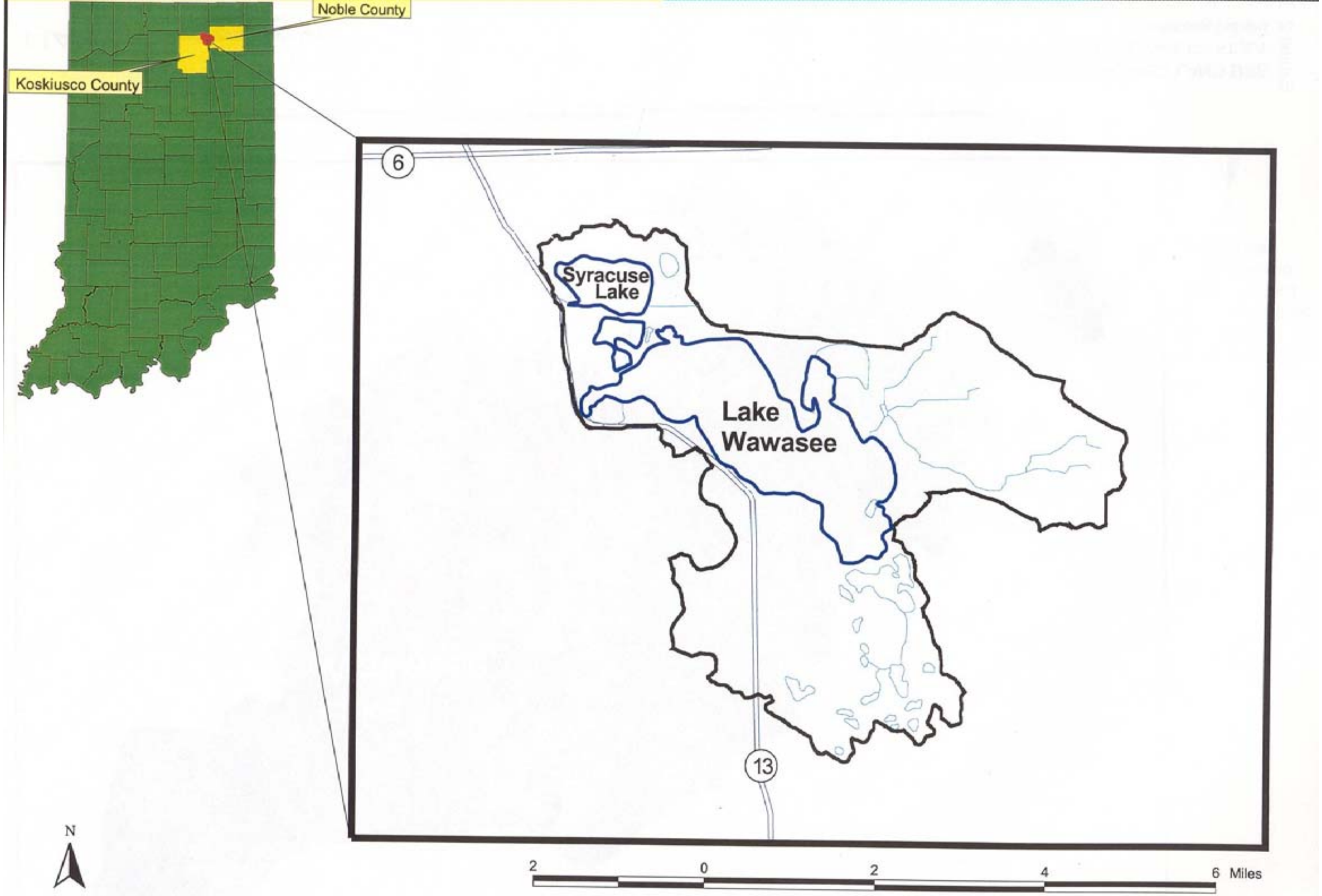
U.S. Department of Agriculture Natural Resources Conservation Service (NRCS), National Soil Survey Center, Soil Survey Laboratory Database, Lincoln, Nebraska, 1998. http://vmhost.cdp.state.ne.us/~nslsoil/soil.html

U.S. Department of Agriculture, Natural Resources Conservation Service. 1994. State Soil Geographic (STATSGO) Database for Indiana. U.S. Department of Agriculture, Natural Resources Conservation Service. Official Soil Series Description Data Access. http://www.in.nrcs.usda.gov/.

U.S. Department of Agriculture, Soil Conservation Service (SCS). *Technical Release No. 20: Computer Program for Project Formulation Hydrology (TR-20)*, Version 2.04, 1992. Water Environment Federation (WEF) and Amercian Society of Civil Engineers (ASCE). 1998. *Urban Runoff Quality Management*. WEF, Alexandria, Virginia.

Wischmeier, W.H. and D.D. Smith. *Predicting Rainfall Erosion Losses – A Guide to Conservation Planning. Agricultural Handbook No. 537*. U.S. Department of Agriculture, Washington D.C. as cited in: Mills, WB; DB Porcella; MJ Ungs; SA Gherini; KV Summers; L Mok; GL Rupp; GL Bowie, and DA Haith, 1985. *Water Quality Assessment: A Screening Procedure for Toxic and Conventional Pollutants in Surface and Ground Water*. EPA/600/6-85/002. Office of Research and Development, Athens, Georgia, 1978.

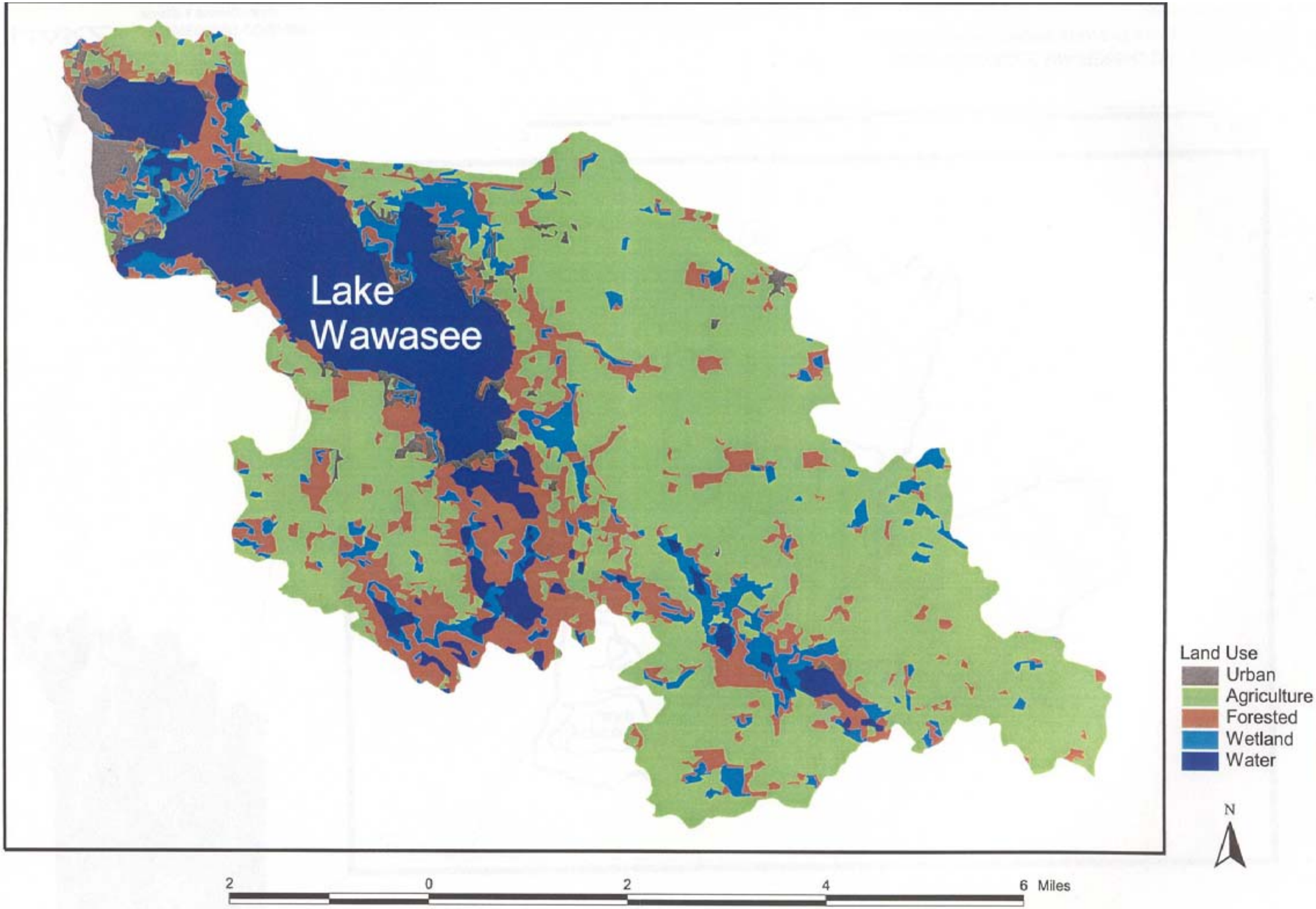
Exhibits 1-46 follow



LAKE WAWASEE WATERSHED LOCATION
LAKE WAWASEE ENGINEERING FEASIBILITY STUDY
Syracuse, Indiana

Exhibit 1

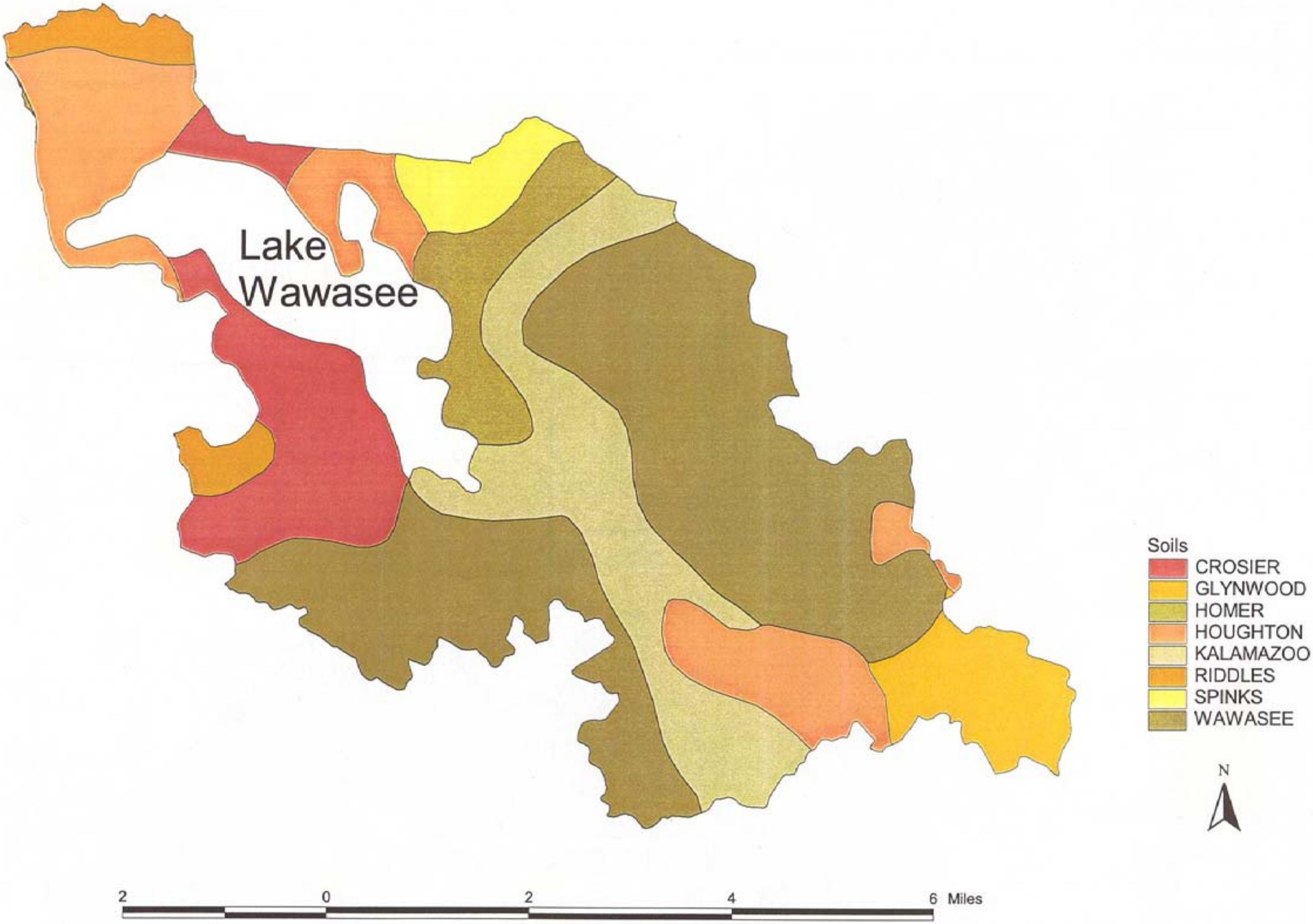
HARZA ENGINEERING COMPANY
WATER & ENVIRONMENT



LAKE WAWASEE WATERSHED LAND USE
LAKE WAWASEE ENGINEERING FEASIBILITY STUDY
Syracuse, Indiana

Exhibit 2

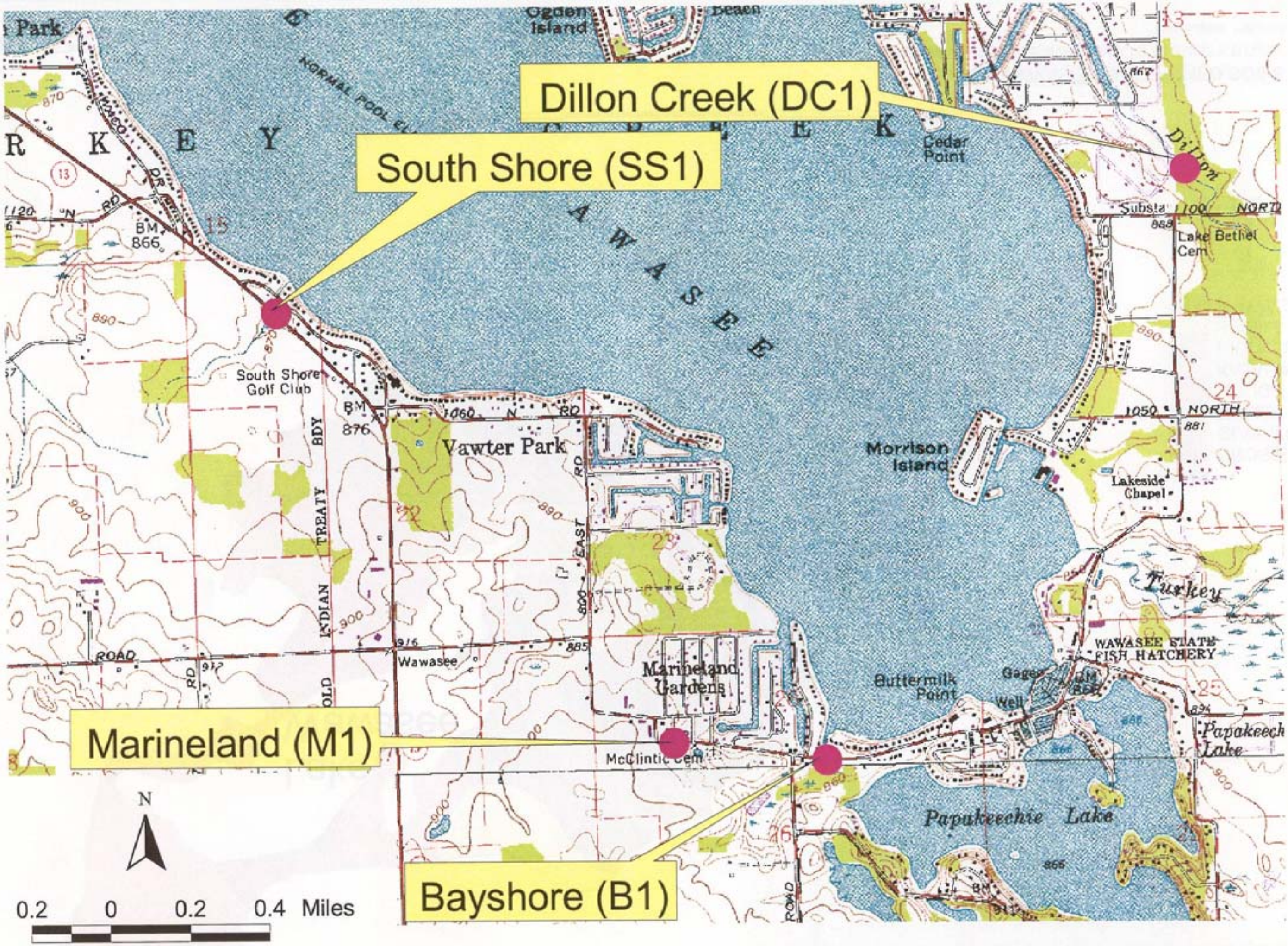
HARZA ENGINEERING COMPANY
WATER & ENVIRONMENT



LAKE WAWASEE WATERSHED SOILS
LAKE WAWASEE ENGINEERING FEASIBILITY STUDY
Syracuse, Indiana

Exhibit 3

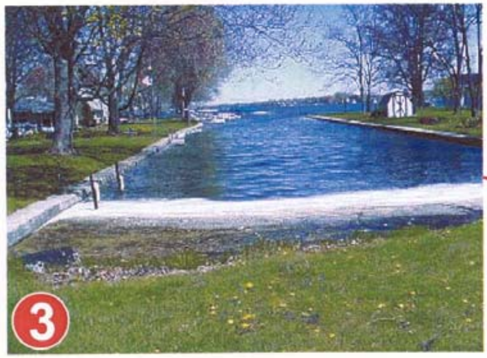
HARZA ENGINEERING COMPANY
WATER & ENVIRONMENT

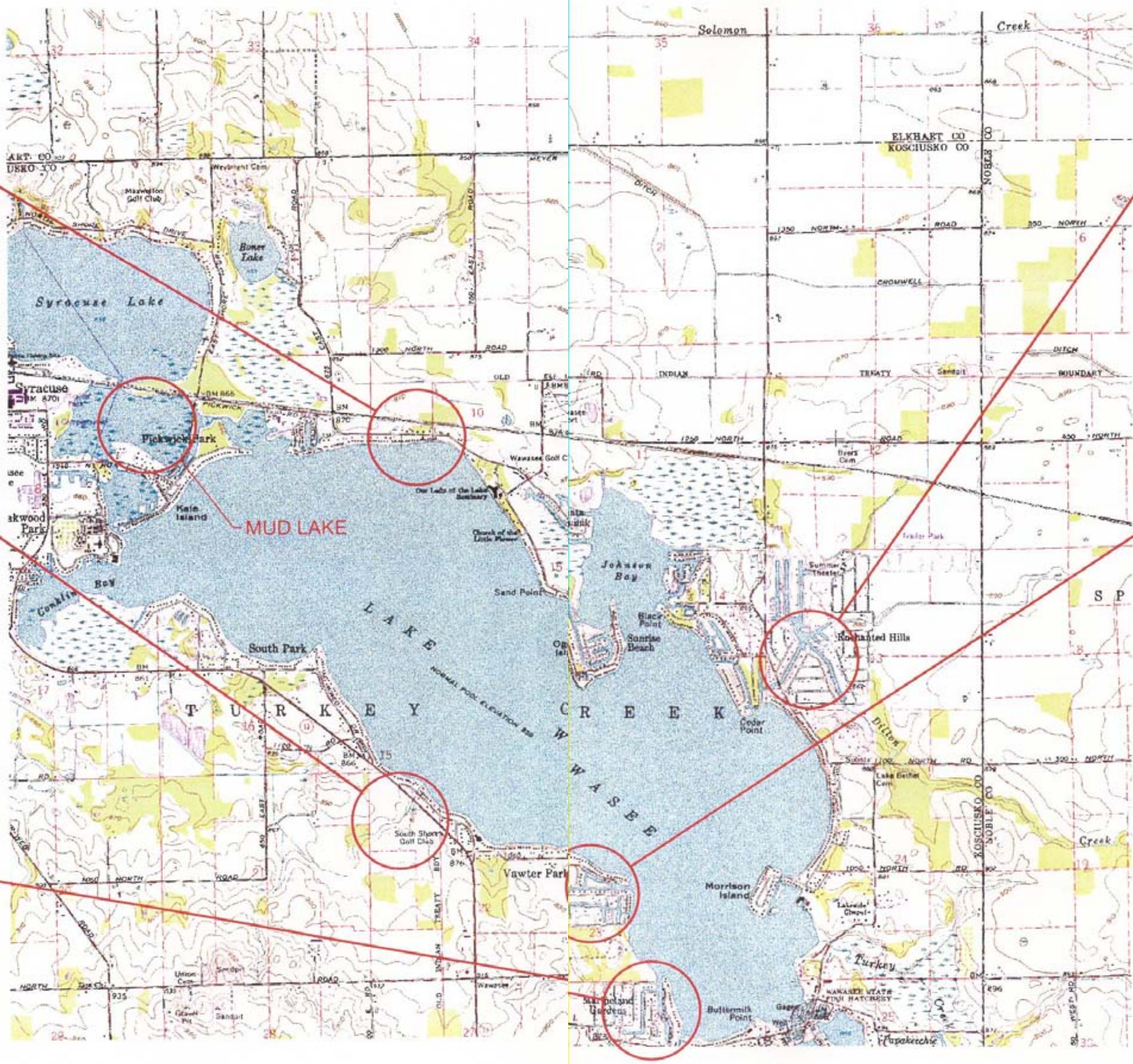


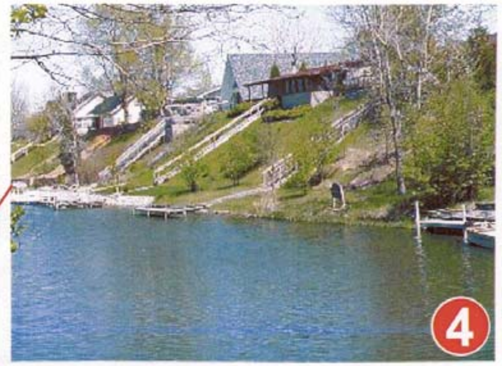
LAKE WAWASEE STORM WATER SAMPLING LOCATIONS
LAKE WAWASEE ENGINEERING FEASIBILITY STUDY
Syracuse, Indiana

Exhibit 4

HARZA ENGINEERING COMPANY
WATER & ENVIRONMENT





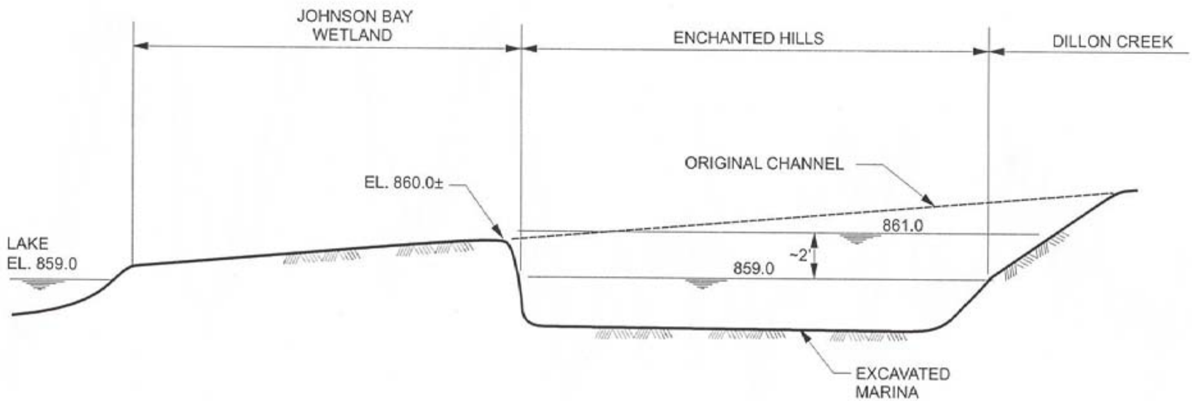


LEGEND:

1. Seawall Refacing Demonstration Project
2. South Shore
3. Bayshore / Marineland
4. Enchanted Hills
5. Leeland Addition

HARZA ENGINEERING COMPANY
WATER & ENVIRONMENT

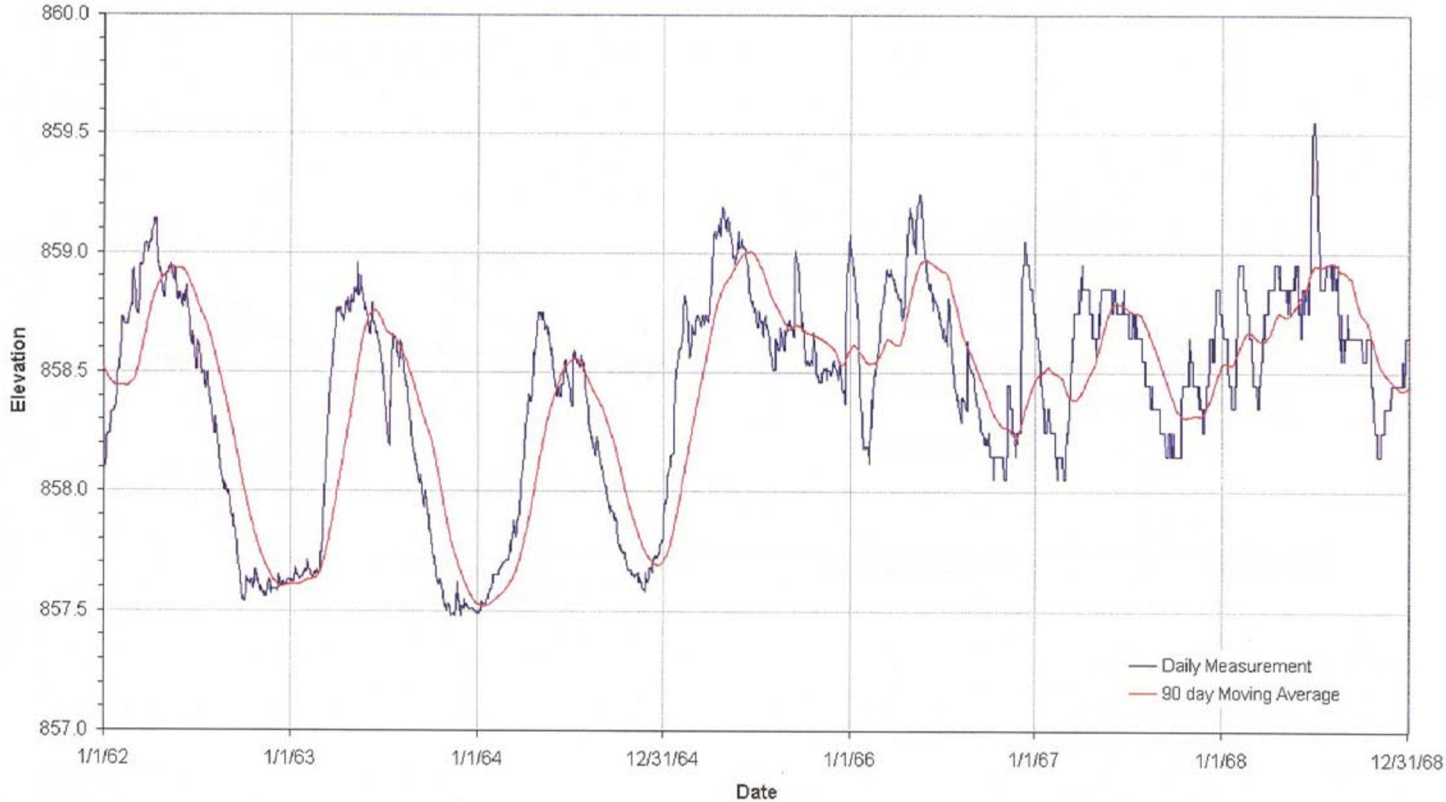
STUDY AREAS
LAKE WAWASEE ENGINEERING FEASIBILITY STUDY
Syracuse, Indiana



FLOW PROFILE DILLON CREEK - WETLAND
LAKE WAWASEE ENGINEERING FEASIBILITY STUDY
Syracuse, Indiana

EXHIBIT 6

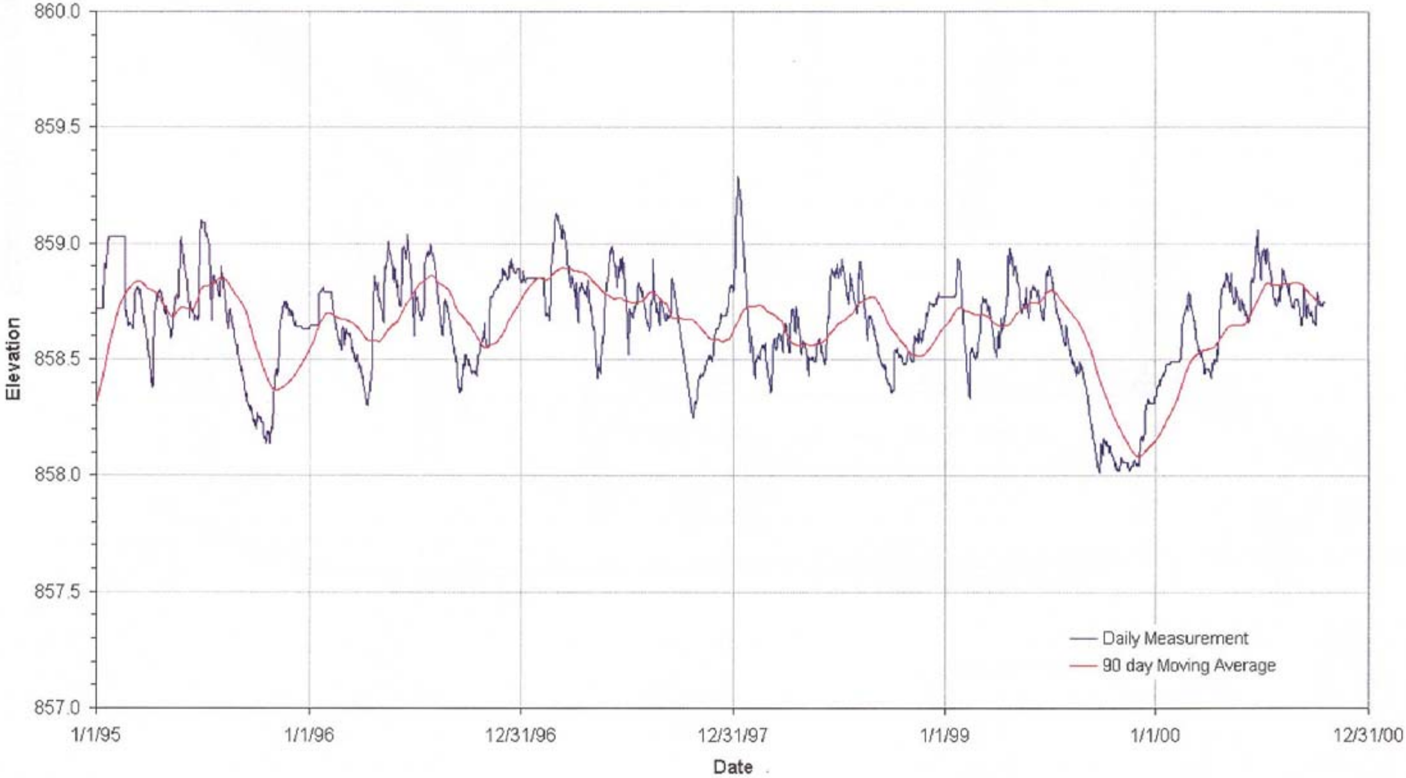
HARZA ENGINEERING COMPANY
WATER & ENVIRONMENT



HISTORICAL SYRACUSE LAKE WATER LEVELS
LAKE WAWASEE ENGINEERING FEASIBILITY STUDY
Syracuse, Indiana

EXHIBIT 7

HARZA ENGINEERING COMPANY
WATER & ENVIRONMENT

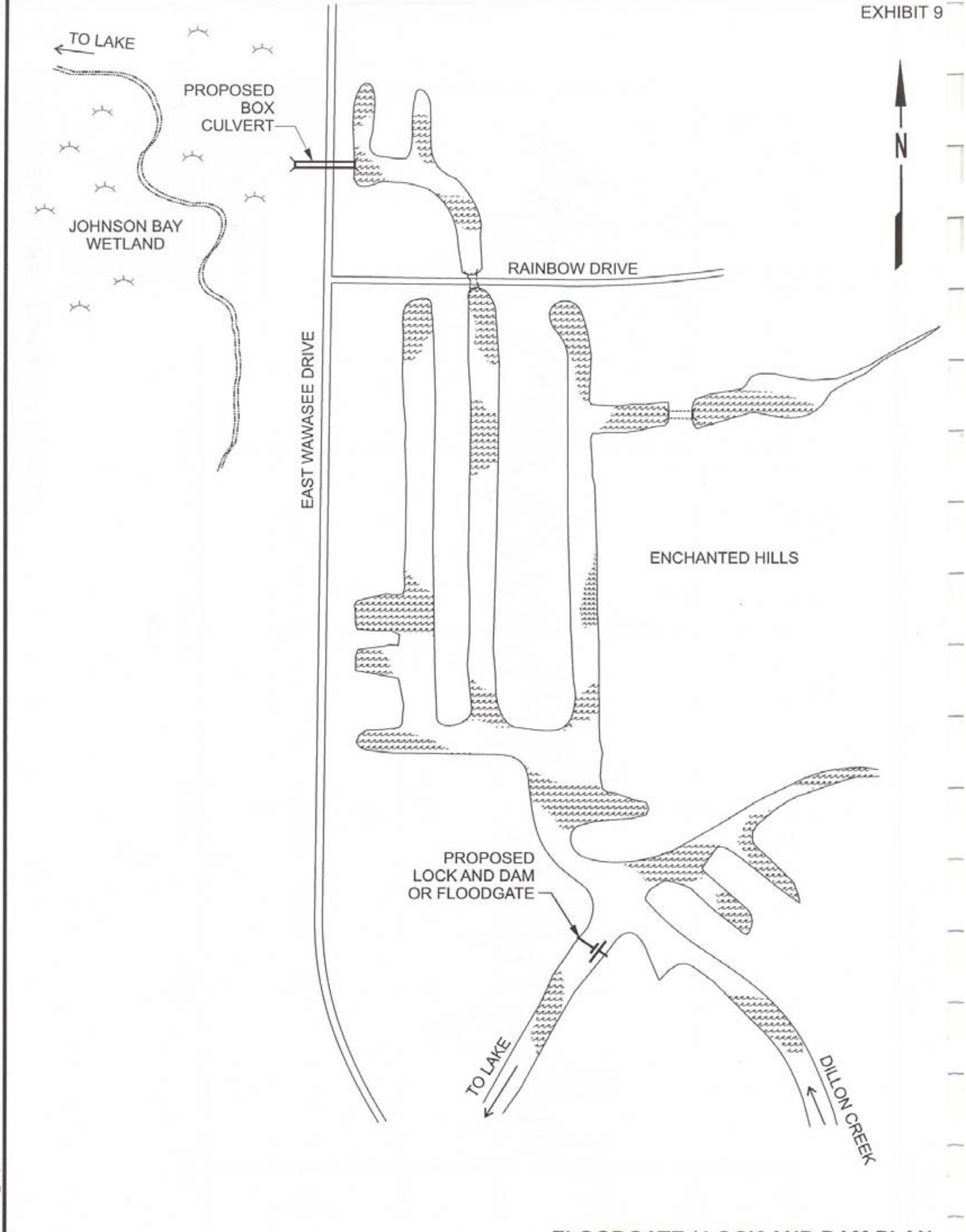


RECENT SYRACUSE LAKE WATER LEVELS
LAKE WAWASEE ENGINEERING FEASIBILITY STUDY
Syracuse, Indiana

EXHIBIT 8

HARZA ENGINEERING COMPANY
WATER & ENVIRONMENT

EXHIBIT 9

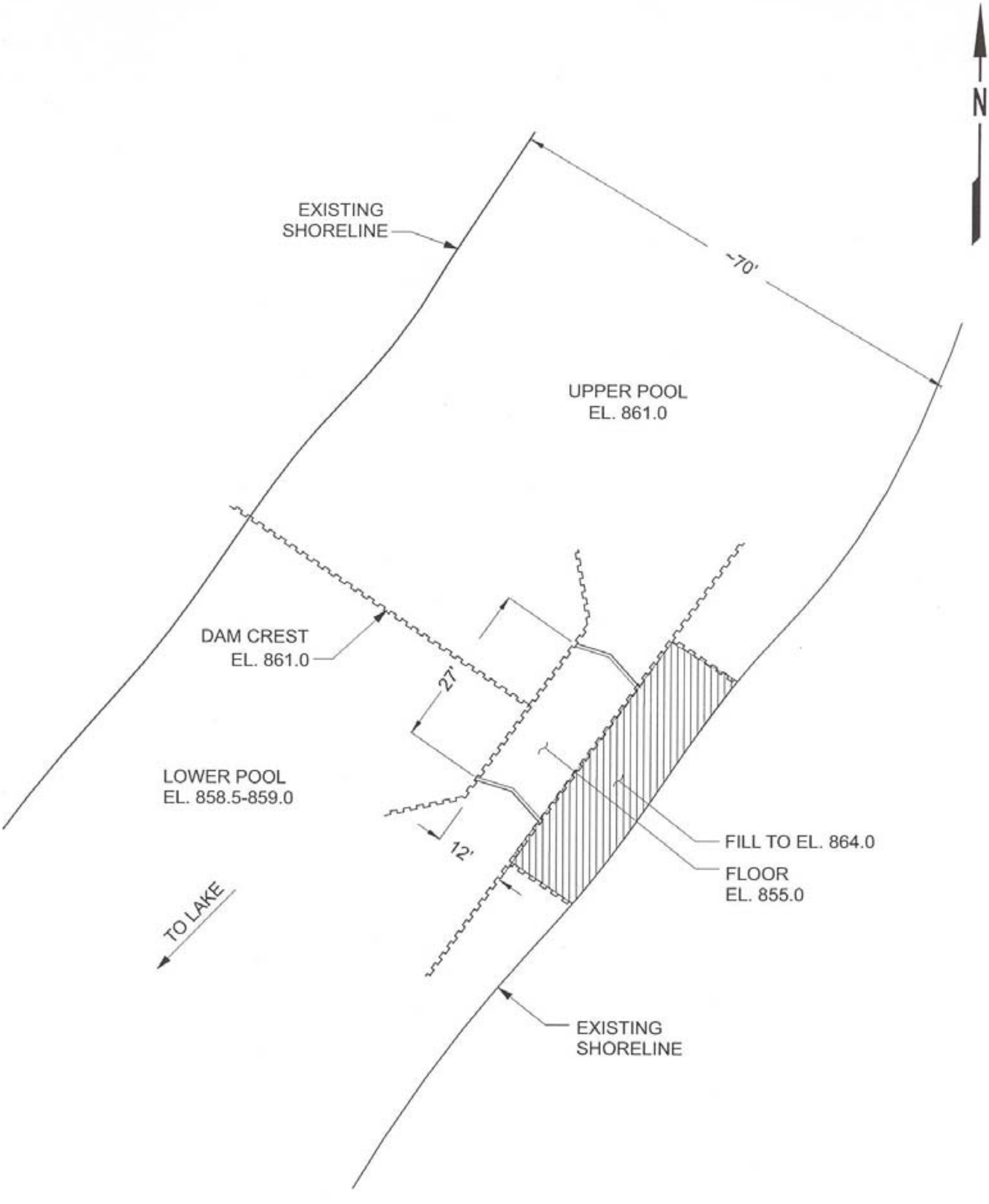


HARZA ENGINEERING COMPANY
WATER & ENVIRONMENT

FLOODGATE / LOCK AND DAM PLAN
LAKE WAWASEE ENGINEERING FEASIBILITY STUDY
Syracuse, Indiana

O:\lake wawasee\location_map.cdr

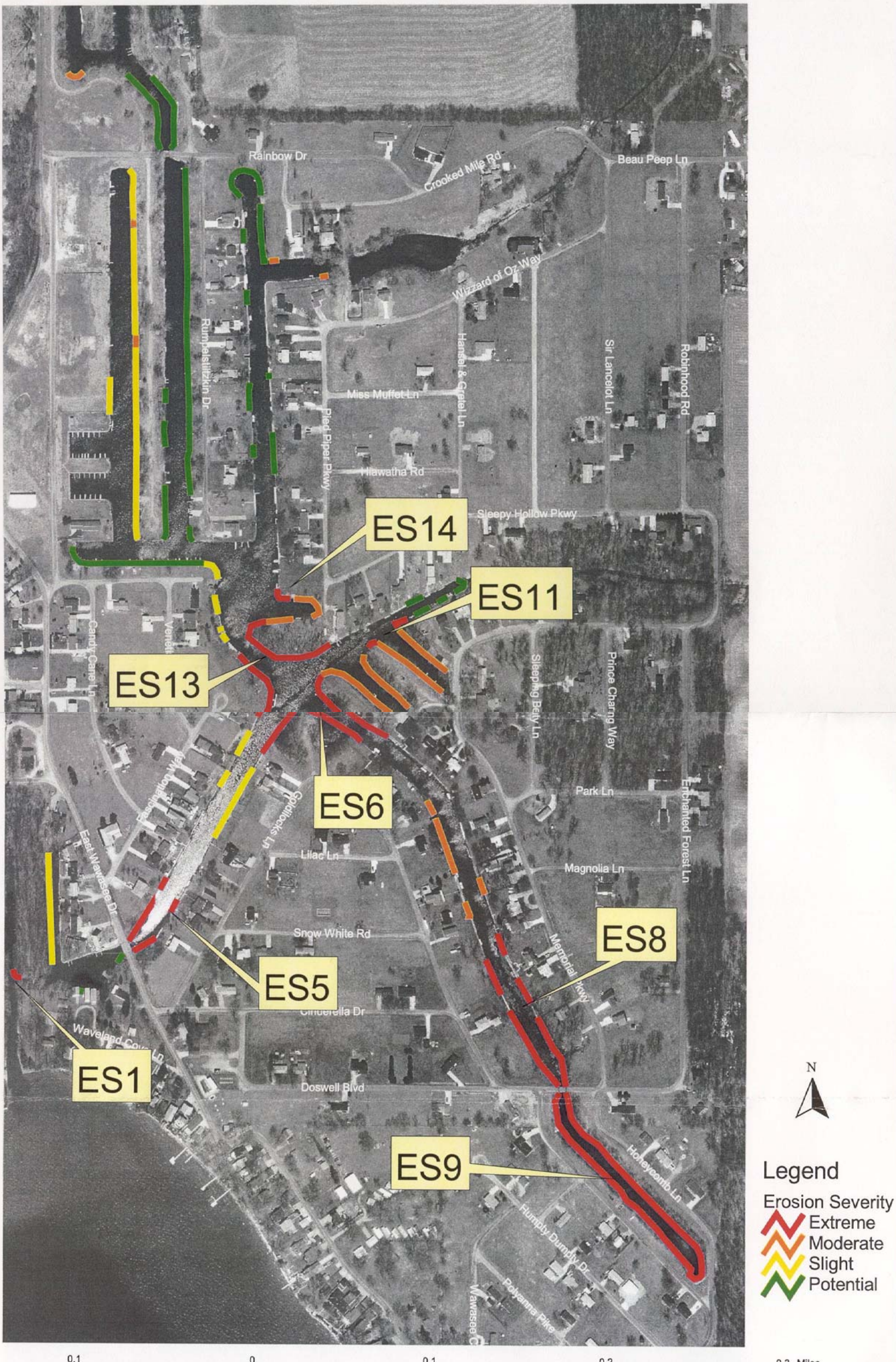
EXHIBIT 10



HARZA ENGINEERING COMPANY
WATER & ENVIRONMENT

LOCK AND DAM
LAKE WAWASEE ENGINEERING FEASIBILITY STUDY
Syracuse, Indiana

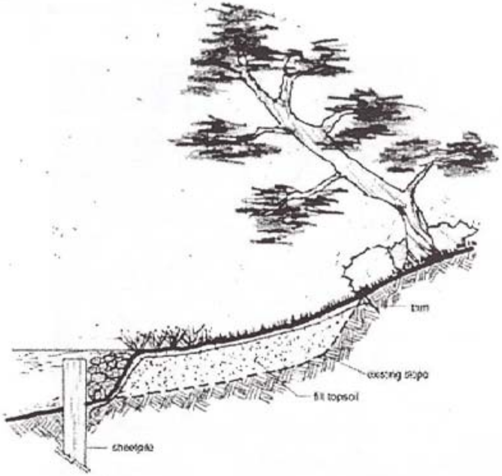
O:\lake wawasee\lock-dam.cdr



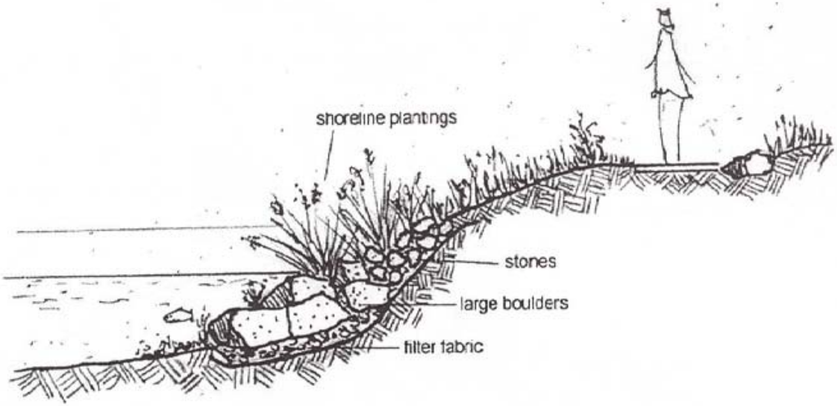
HARZA ENGINEERING COMPANY
WATER & ENVIRONMENT

ENCHANTED HILLS EROSION SURVEY
LAKE WAWASEE ENGINEERING FEASIBILITY STUDY
Syrcause, Indiana

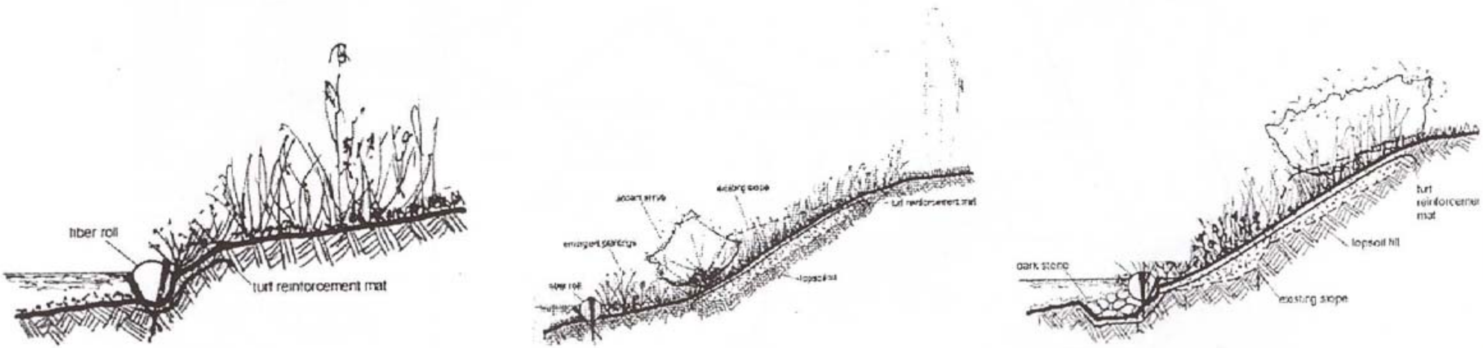
Exhibit 11



SHEETPILING



BOULDER AND STONE

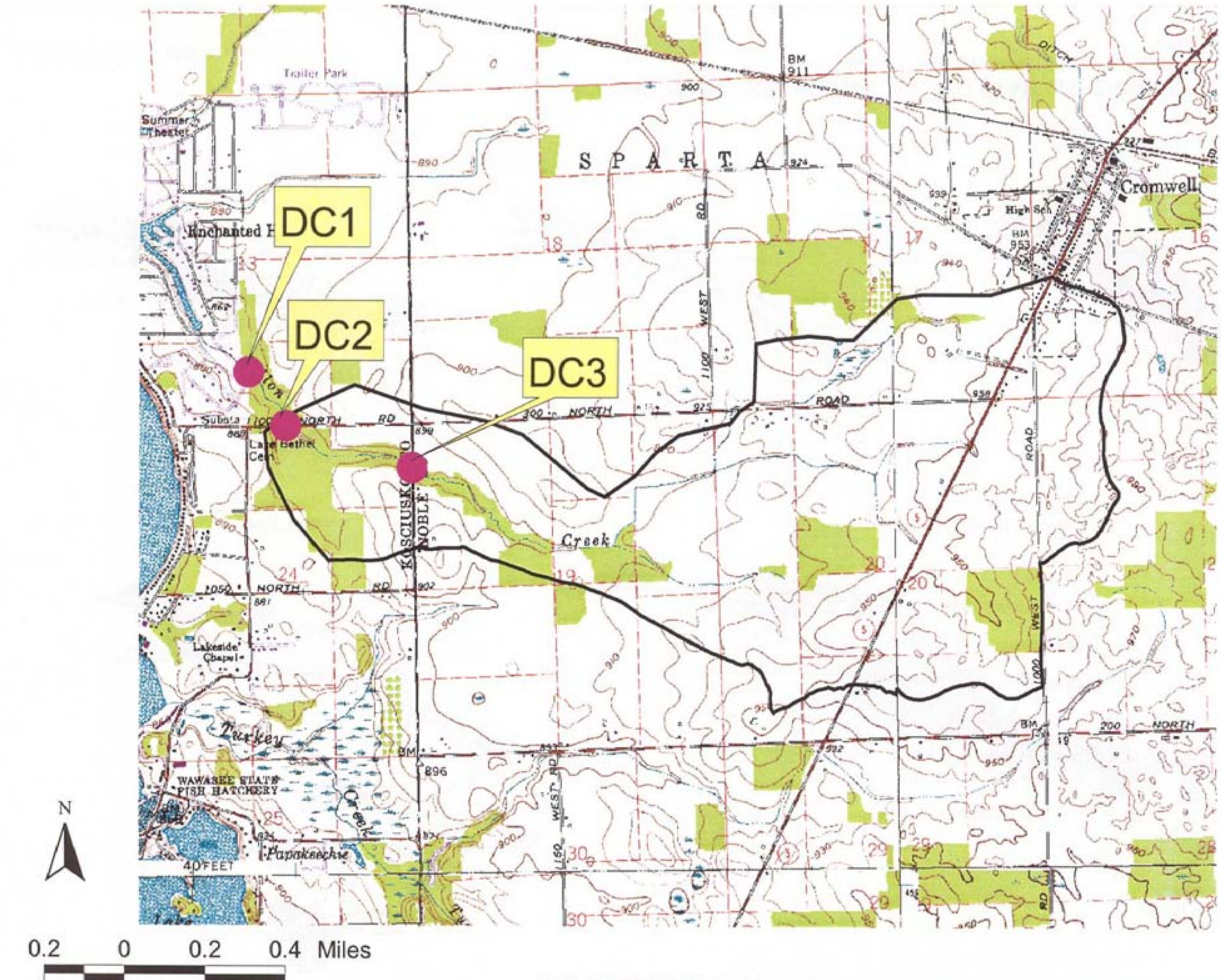


FIBER ROLLS AND HERBACEOUS TREATMENTS

SHORELINE REVEGETATION AND STABILIZATION TREATMENTS
LAKE WAWASEE ENGINEERING FEASIBILITY STUDY
Syracuse, Indiana

EXHIBIT 12

HARZA ENGINEERING COMPANY
WATER & ENVIRONMENT



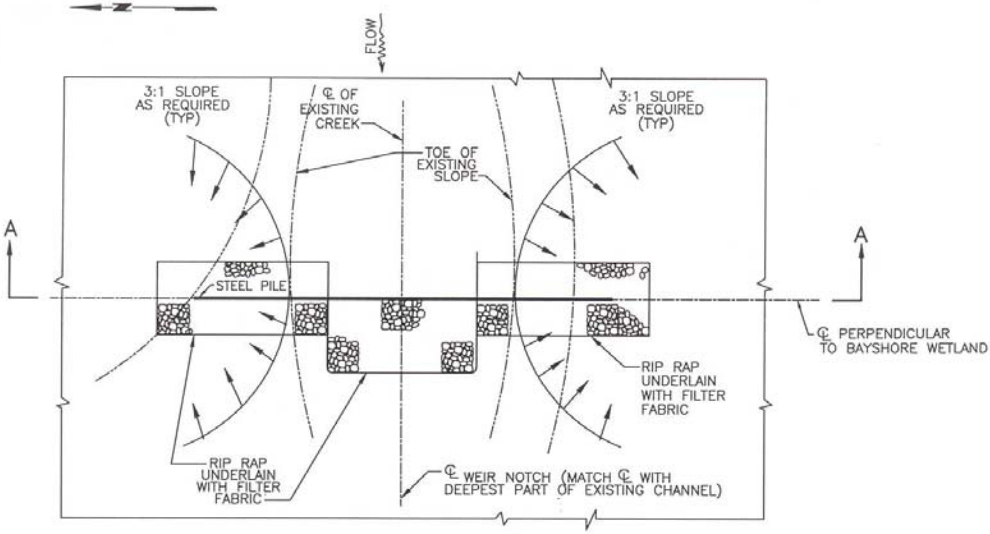
DILLON CREEK BIOASSESSMENT LOCATIONS AND DC2 WATERSHED BOUNDARY

LAKE WAWASEE ENGINEERING FEASIBILITY STUDY

Syracuse, Indiana

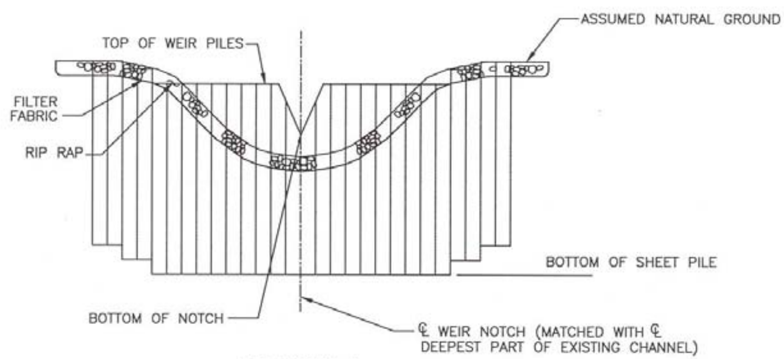
Exhibit 13

HARZA ENGINEERING COMPANY
WATER & ENVIRONMENT



PLAN

NOT TO SCALE



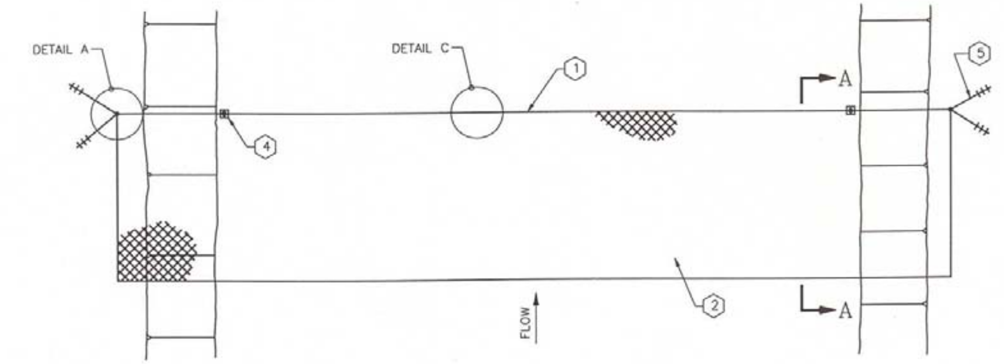
SECTION A-A

NOT TO SCALE

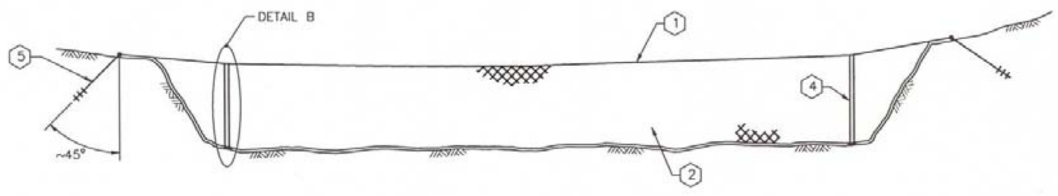
TYPICAL SHEET PILE DAM PLAN AND SECTION

LAKE WAWASEE ENGINEERING FEASIBILITY STUDY
Syracuse, Indiana

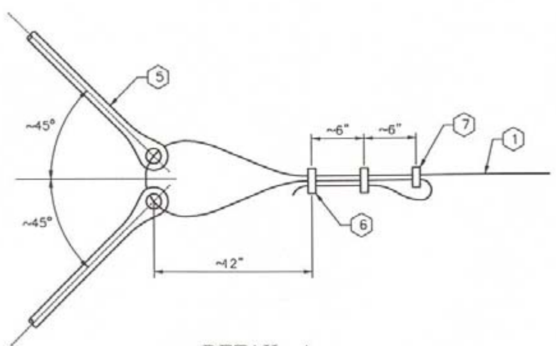
HARZA ENGINEERING COMPANY
WATER & ENVIRONMENT



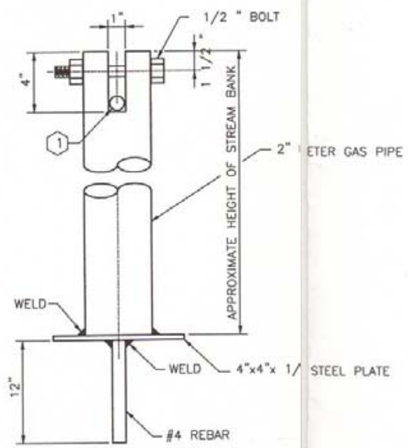
PLAN
(NTS)



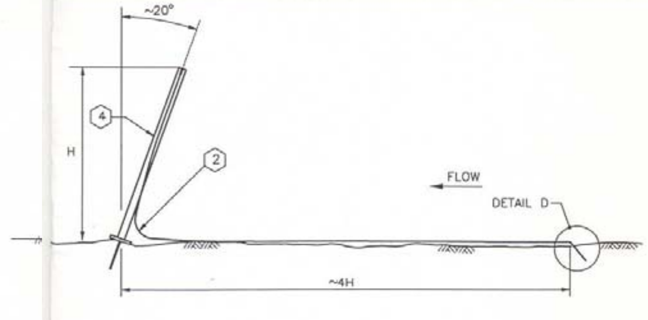
PROFILE
(NTS)



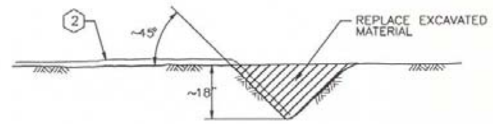
DETAIL A
(NTS)



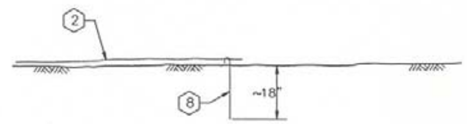
DETAIL B
(NTS)



SECTION A-A
(NTS)

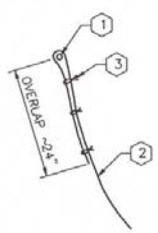


ALTERNATIVE A



ALTERNATIVE B

DETAIL D
(NTS)



DETAIL C
(NTS)

Site Selection

The dam should be constructed in a location where the incised channel narrows and the upstream flood plain is broad. These parameters will minimize the amount of materials necessary to construct the dam and maximize the overbank flood storage and wetland habitat. The dam should be constructed perpendicular to the channel with the maximum cable sag in the center of the channel, which should prevent high flows from attacking the stream banks.

The height, at the point of maximum cable sag over the stream channel should not exceed five feet. However, some allowance should be given for the additional cable sag after the dam is fully loaded with sediment. Accordingly, the distance between the maximum sag and the stream channel might initially be as much as six or seven feet. The cable is expected to sag in the vertical direction as well as bow in the downstream direction. These deformations are due, in part, to cable stretch and tie and soil anchor deformation.

Site Preparation

The ground along the alignment of the cable should be cleared of woody vegetation. The clearing, however, should be kept to a minimum in order to maintain the vegetation of the site. Woody vegetation upstream of the cable should be cleared to facilitate the placement of the chain link fence.

Dam Construction

The soil anchors should be installed at a 45-degree angle of each other. The heads of the anchors, once completely augered into the ground, should abut to each other in order to maintain equal force on each anchor.

The chain link fence facing of the dam should be draped over the cable and attached to itself with reinforcing bar tie wires. The chain link fence should run upstream a length equal to about 4 times the height of the dam, maintaining contact with the streambed the entire length. The upstream ends of the chain link fence should be secured in an excavated trench or by J-hooks made from #3 rebar. The seam between runs of chain link fence should be tied with reinforcing bar tie wires.

Parts List

1. Steel Cable, 3/8" to 1/2" diameter
2. Galvanized Chainlink Fencing
3. Reinforcing Bar Tie Wire
4. Stanchion
5. Soil Anchors, 48" long
6. Cable Clamps, 1/2 to 3/4
7. Cable Clamps, 3/8 to 1/2
8. J-hook, #3 rebar

GENERIC PLAN, PROFILE, SECTION AND DETAILS
LAKE WAWASEE ENGINEERING FEASIBILITY STUDY
Syracuse, Indiana

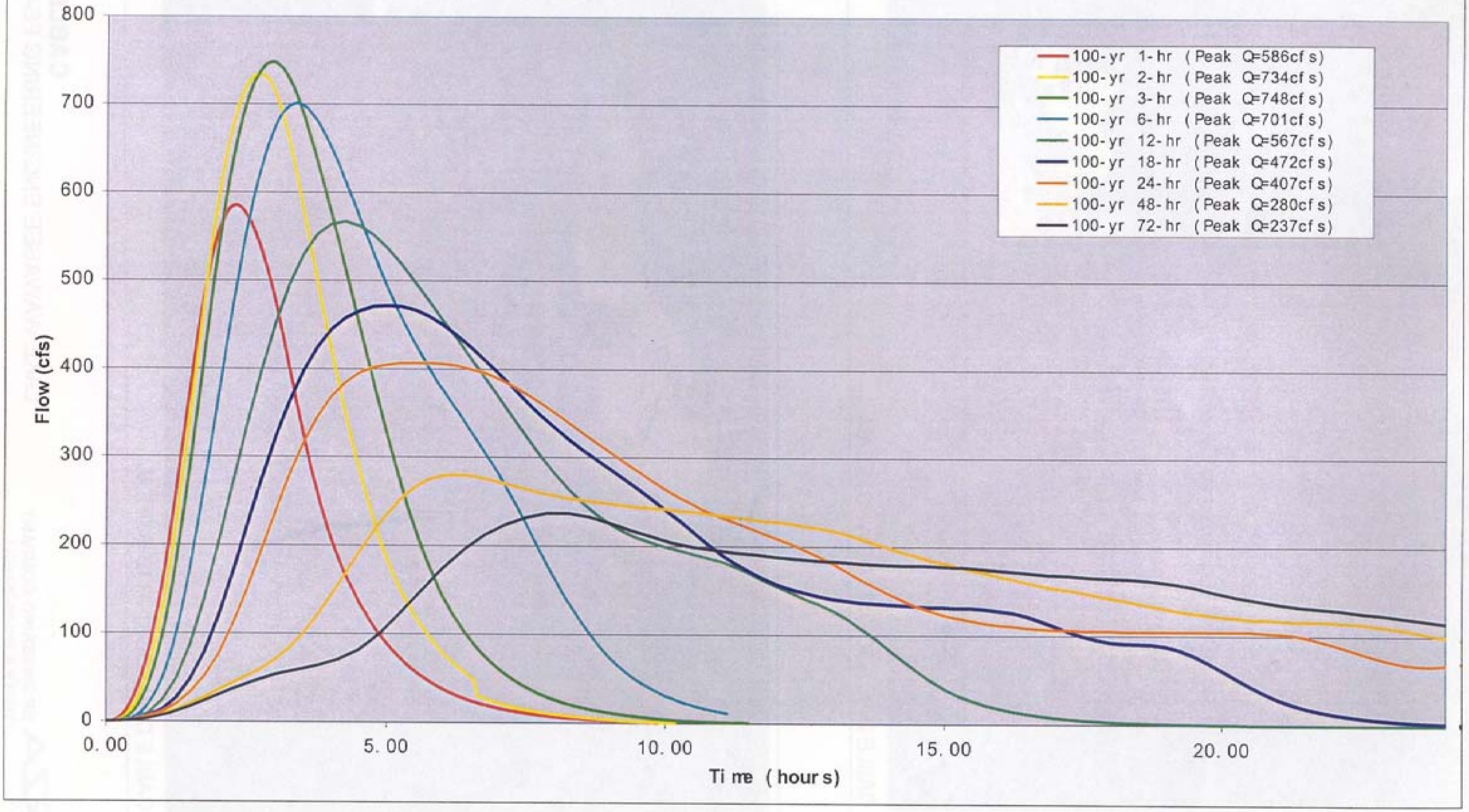
HARZA ENGINEERING COMPANY
WATER & ENVIRONMENT

CABLE DAM LOOKING DOWNSTREAM

CABLE DAM LOOKING UPSTREAM

CABLE DAM PHOTOS
LAKE WAWASEE ENGINEERING FEASIBILITY STUDY
Syracuse, Indiana

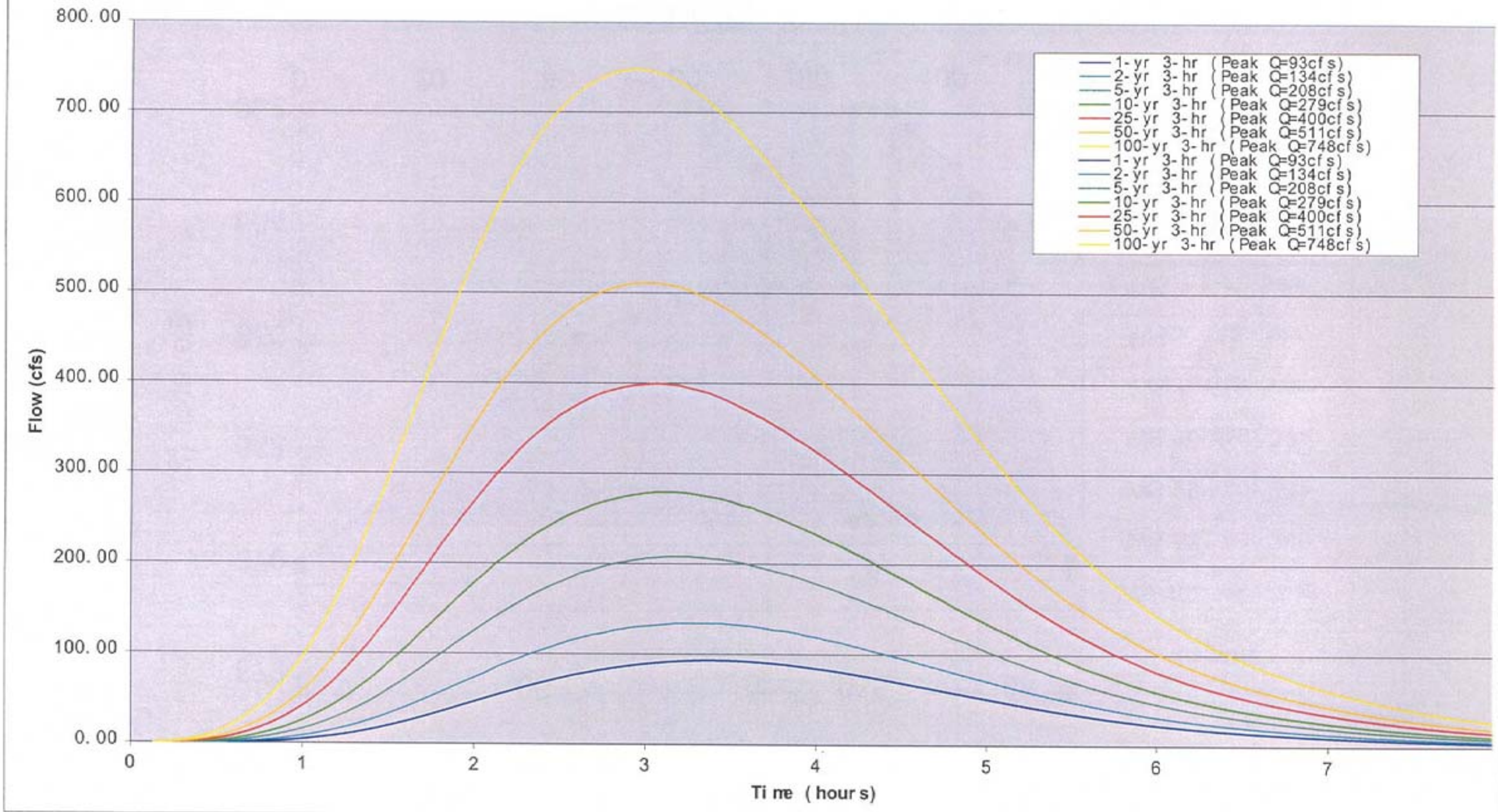
HARZA ENGINEERING COMPANY
WATER & ENVIRONMENT



DC2 HYDROLOGIC SENSITIVITY ANALYSIS
LAKE WAWASEE ENGINEERING FEASIBILITY STUDY
Syracuse, Indiana

EXHIBIT 17

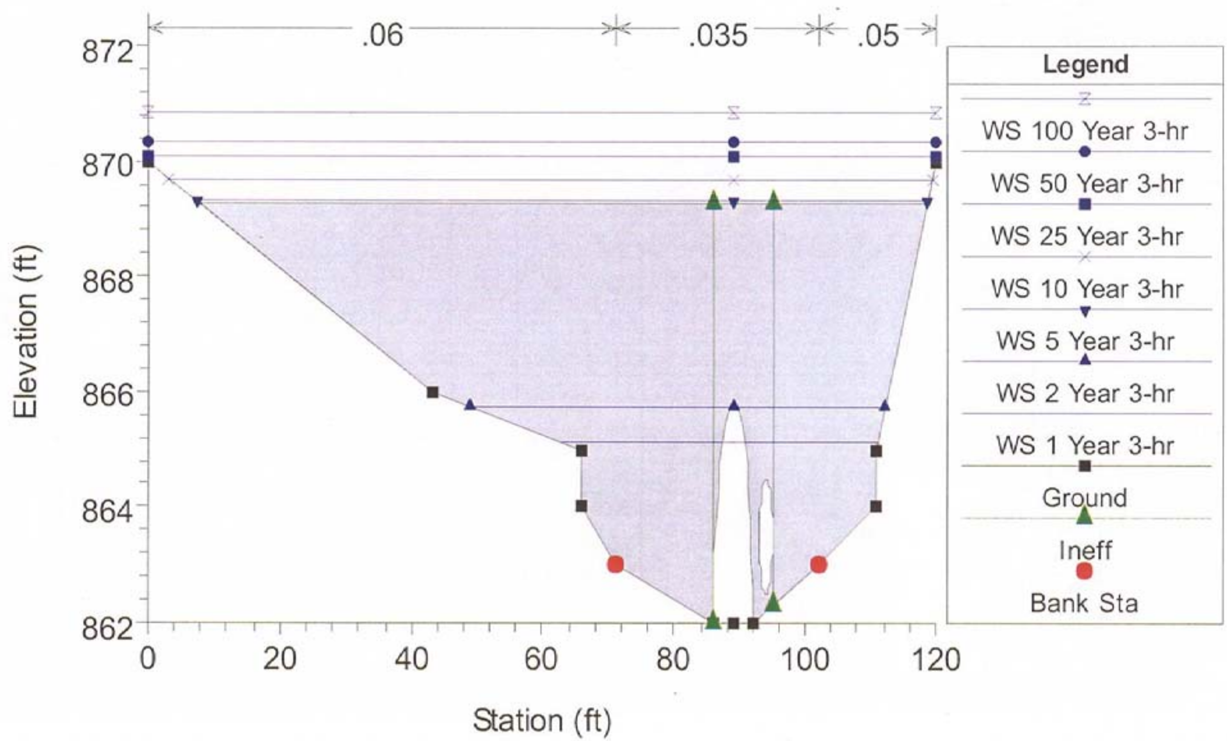
HARZA ENGINEERING COMPANY
WATER & ENVIRONMENT



HARZA ENGINEERING COMPANY
WATER & ENVIRONMENT

DC2 RUNOFF HYDROGRAPHS
LAKE WAWASEE ENGINEERING FEASIBILITY STUDY
Syracuse, Indiana

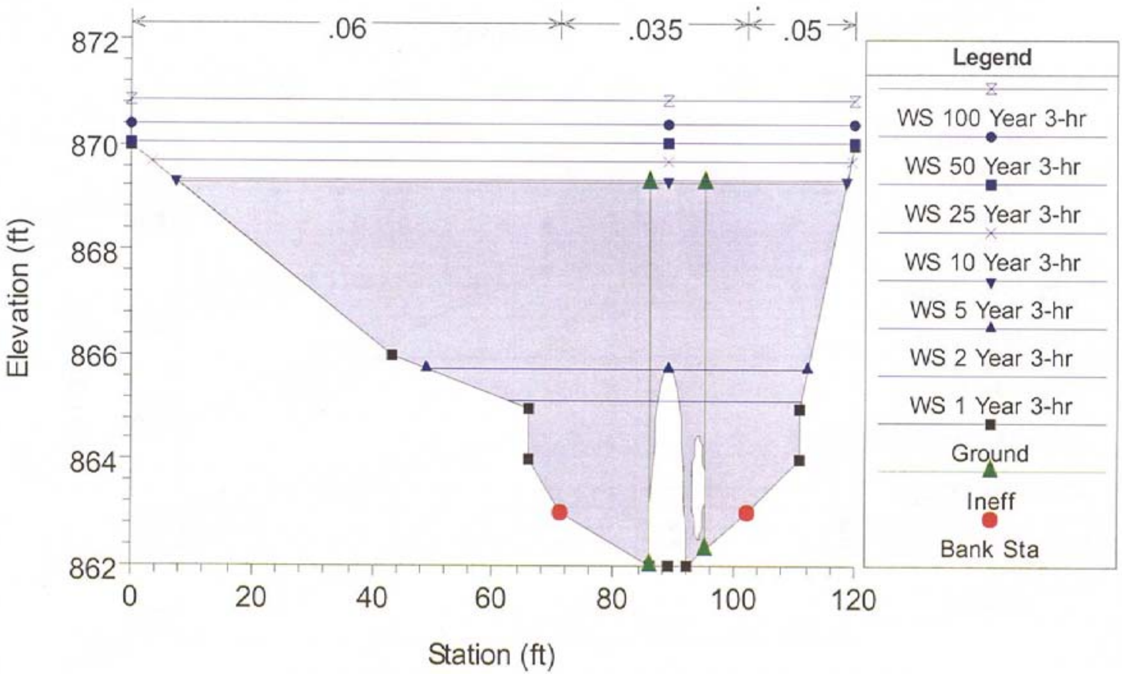
EXHIBIT 18



DILLON CREEK FLOW AT 1100 NORTH ROAD
CULVERT WITHOUT SHEETPILE DAM AT DC2
LAKE WAWASEE ENGINEERING FEASIBILITY STUDY
Syracuse, Indiana

EXHIBIT 19

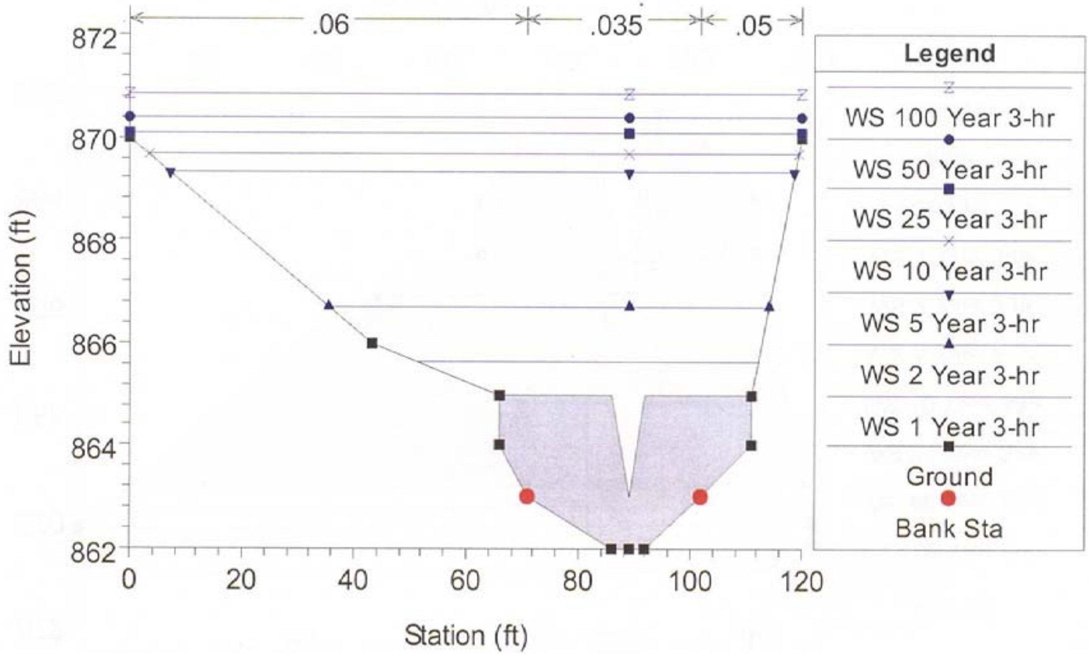
HARZA ENGINEERING COMPANY
WATER & ENVIRONMENT



DILLON CREEK FLOW AT 1100 NORTH ROAD
CULVERT WITH SHEETPILE DAM AT DC2
LAKE WAWASEE ENGINEERING FEASIBILITY STUDY
Syracuse, Indiana

EXHIBIT 20

HARZA ENGINEERING COMPANY
WATER & ENVIRONMENT



HARZA ENGINEERING COMPANY
WATER & ENVIRONMENT

DILLON CREEK FLOW AT SHEETPILE DAM AT DC2

LAKE WAWASEE ENGINEERING FEASIBILITY STUDY

Syracuse, Indiana

EXHIBIT 21

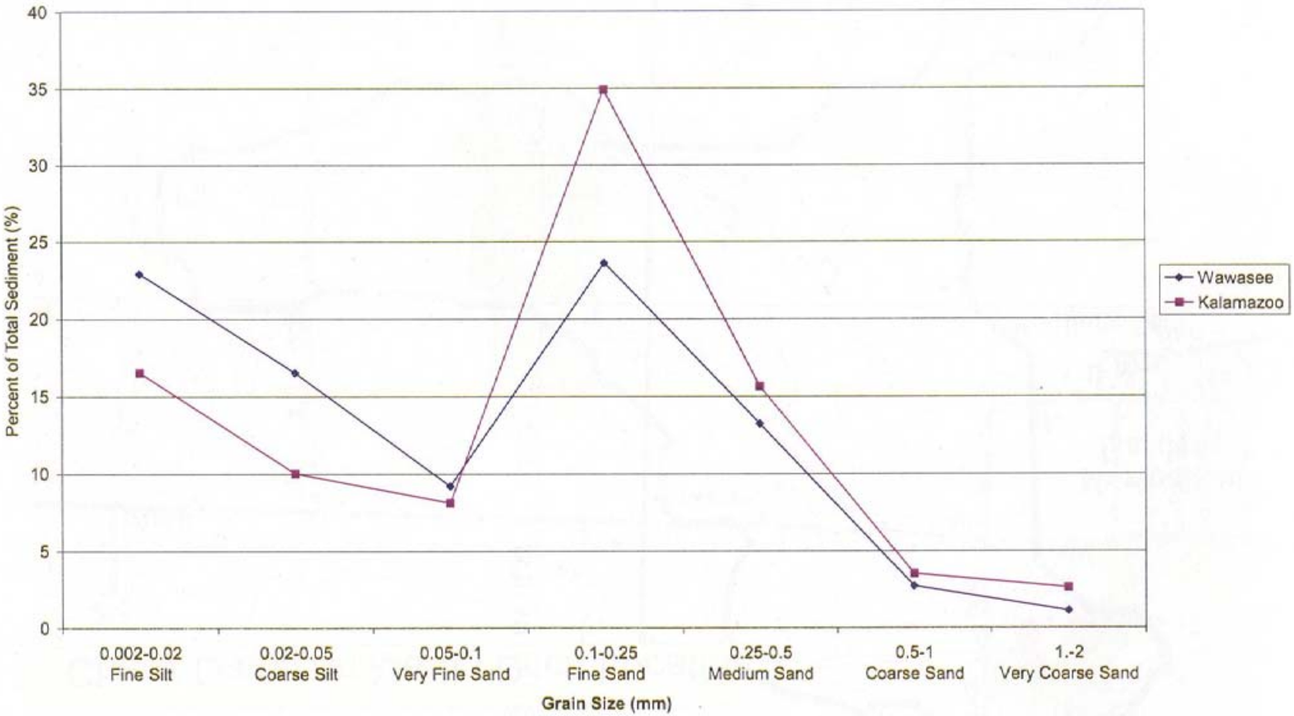


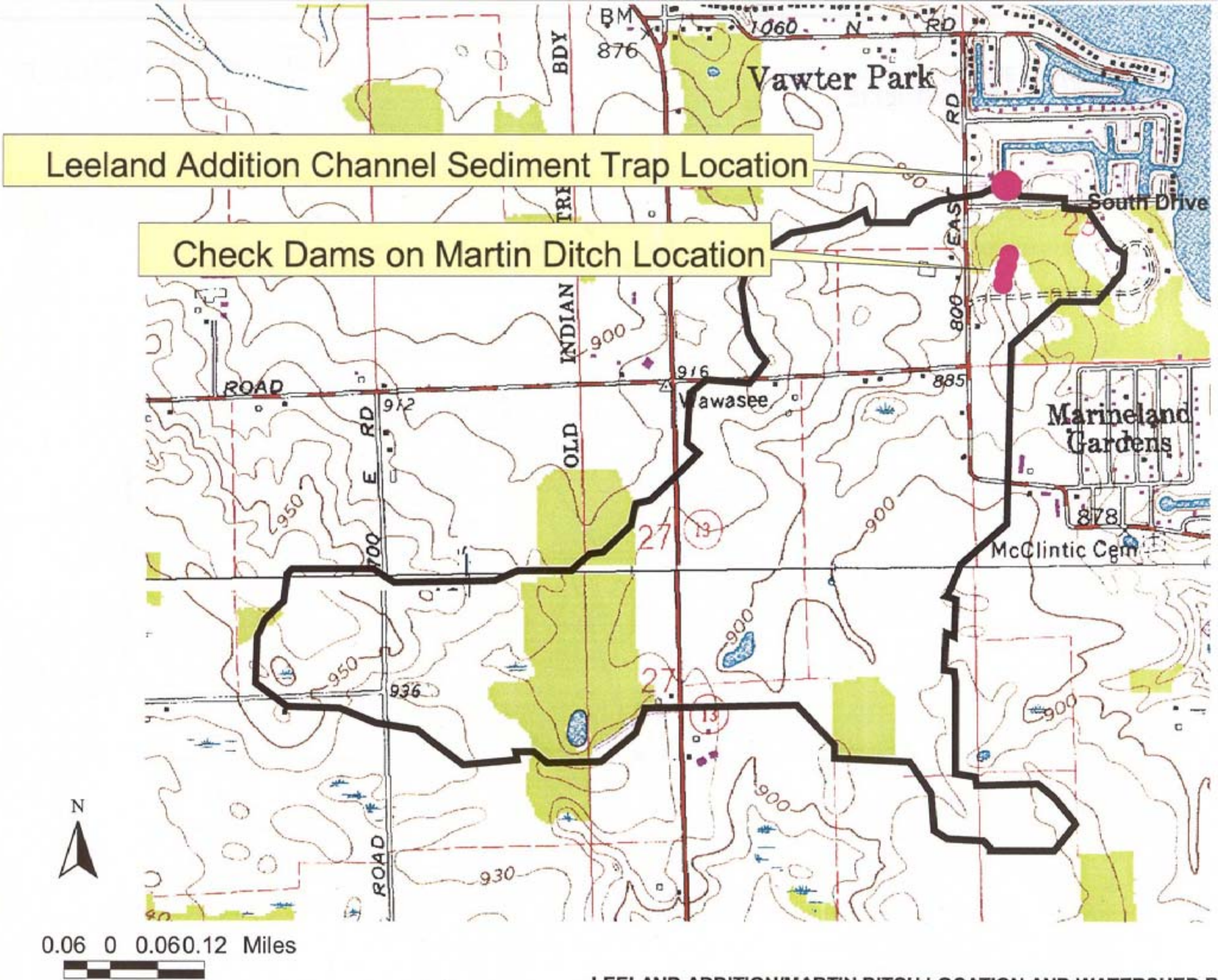
EXHIBIT 22

SEDIMENT SIZE DISTRIBUTION FOR DC2

LAKE WAWASEE ENGINEERING FEASIBILITY STUDY

Syracuse, Indiana

HARZA ENGINEERING COMPANY
WATER & ENVIRONMENT



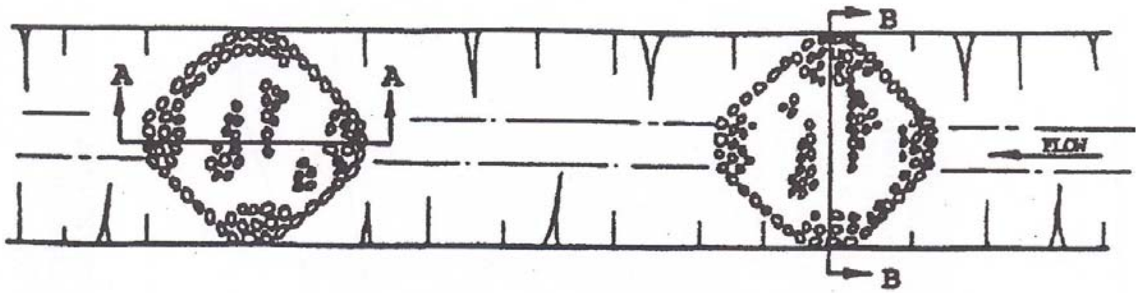
LEELAND ADDITION/MARTIN DITCH LOCATION AND WATERSHED BOUNDARY

LAKE WAWASEE ENGINEERING FEASIBILITY STUDY

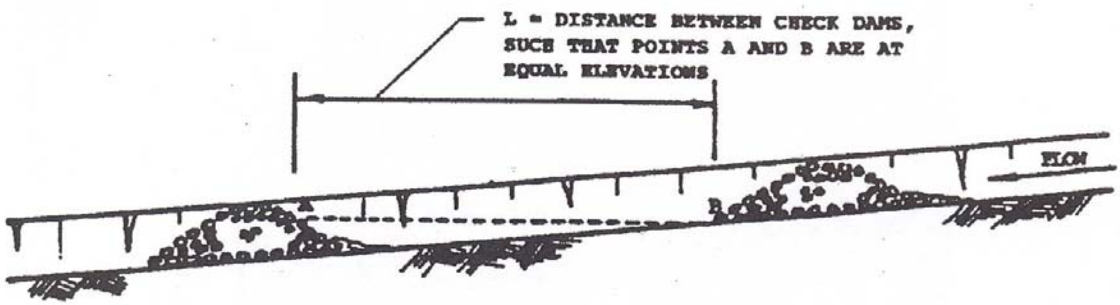
Syracuse, Indiana

Exhibit 23

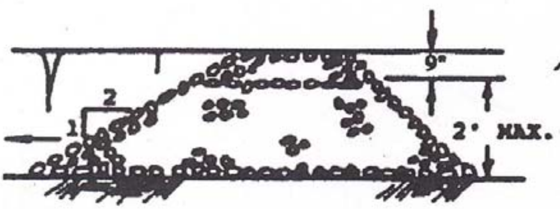
HARZA ENGINEERING COMPANY
WATER & ENVIRONMENT



PLAN VIEW

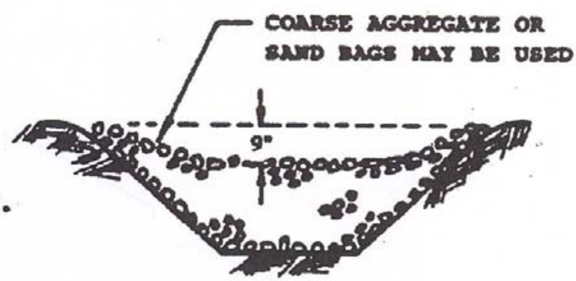


CROSS-SECTION



SECTION A-A

NOTE: CHECK DAMS GREATER THAN TWO FEET IN DEPTH MAY SERIOUSLY IMPACT THE FLOW CHARACTERISTICS OF THE DITCH.

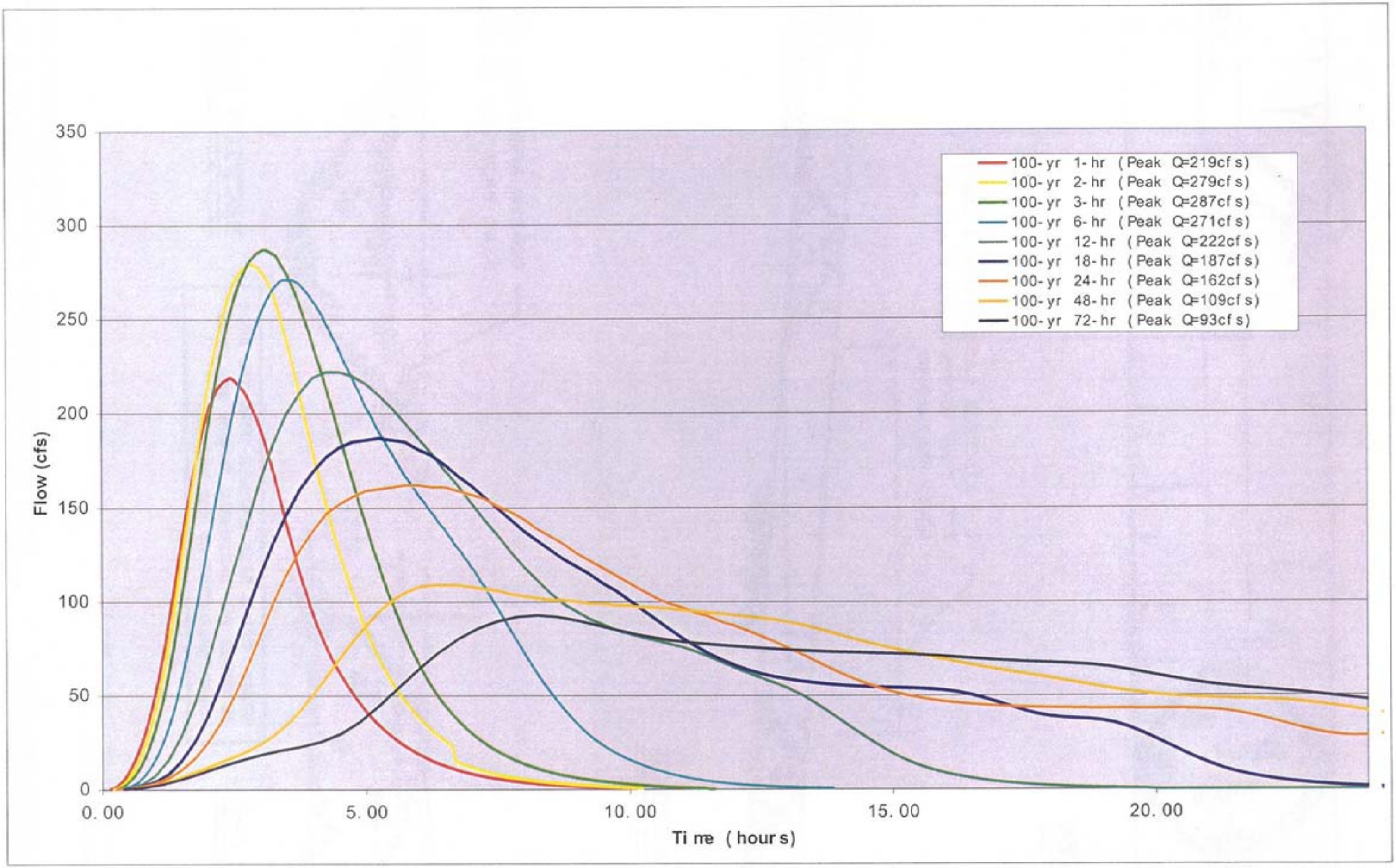


SECTION B-B

Source: Modified from the Erosion Control Manual, Okaland County, Michigan

HARZA ENGINEERING COMPANY
WATER & ENVIRONMENT

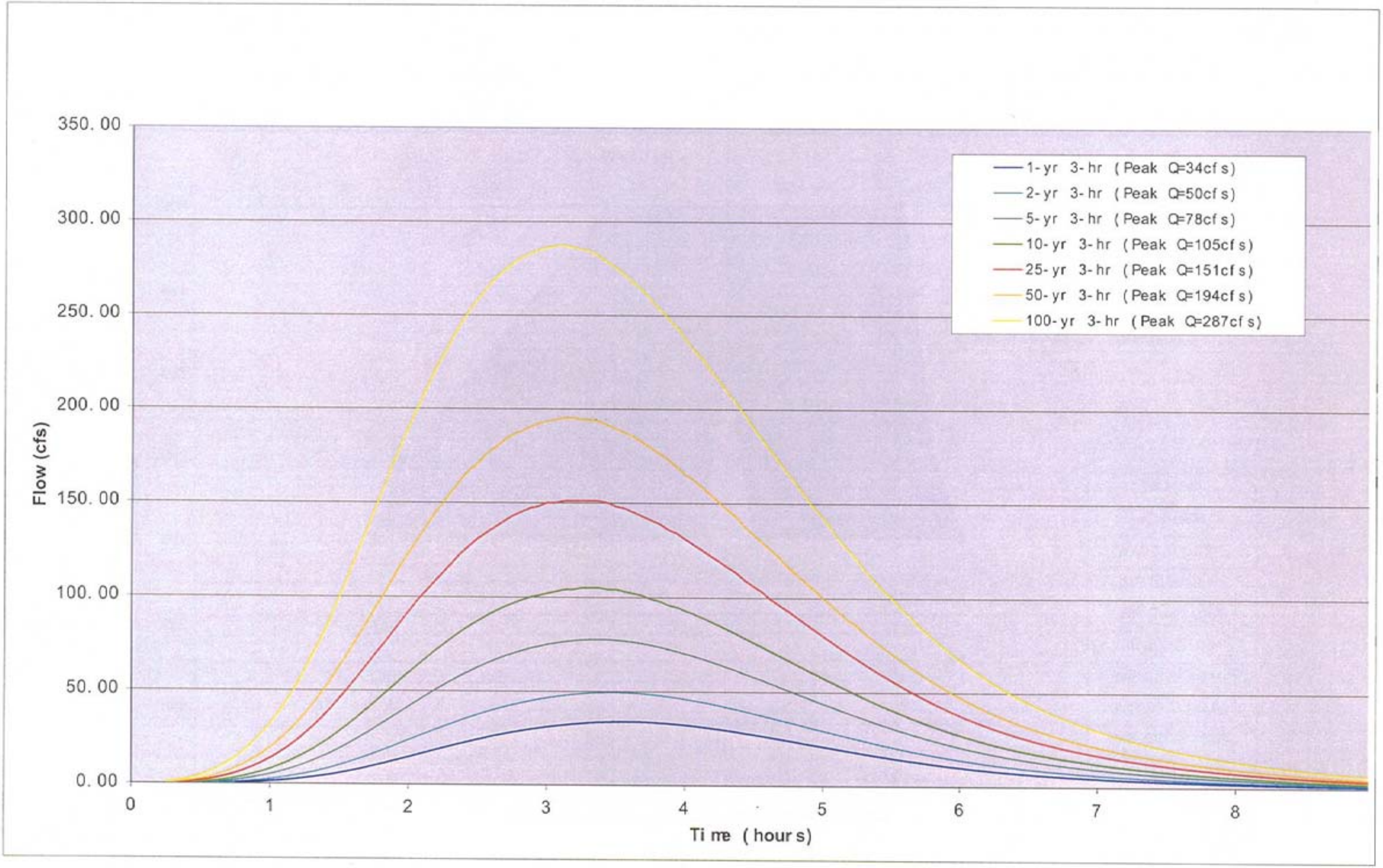
CHECK DAM PLANS
LAKE WAWASEE ENGINEERING FEASIBILITY STUDY
Syracuse, Indiana



LEELAND ADDITION/MARTIN DITCH
HYDROLOGIC SENSITIVITY ANALYSIS
LAKE WAWASEE ENGINEERING FEASIBILITY STUDY
Syracuse, Indiana

EXHIBIT 25

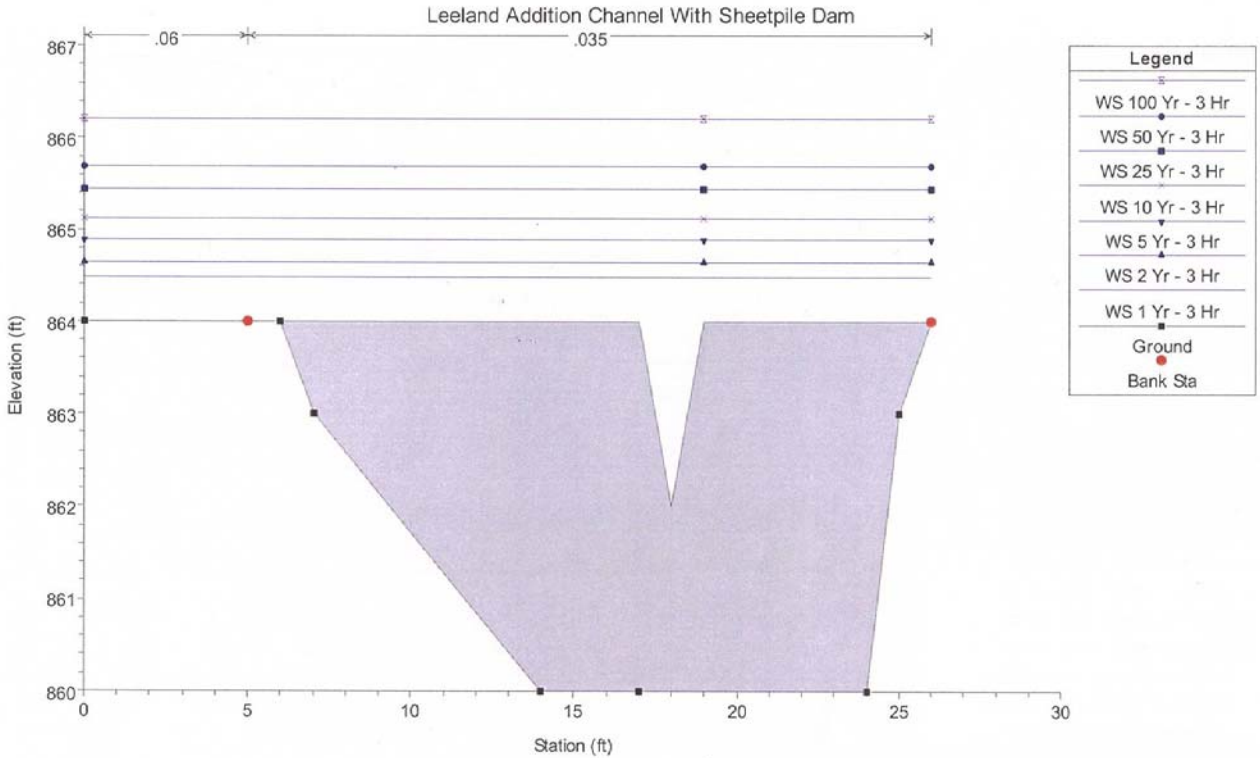
HARZA ENGINEERING COMPANY
WATER & ENVIRONMENT



LEELAND ADDITION/MARTIN DITCH
RUNOFF HYDROGRAPHS
LAKE WAWASEE ENGINEERING FEASIBILITY STUDY
Syracuse, Indiana

EXHIBIT 26

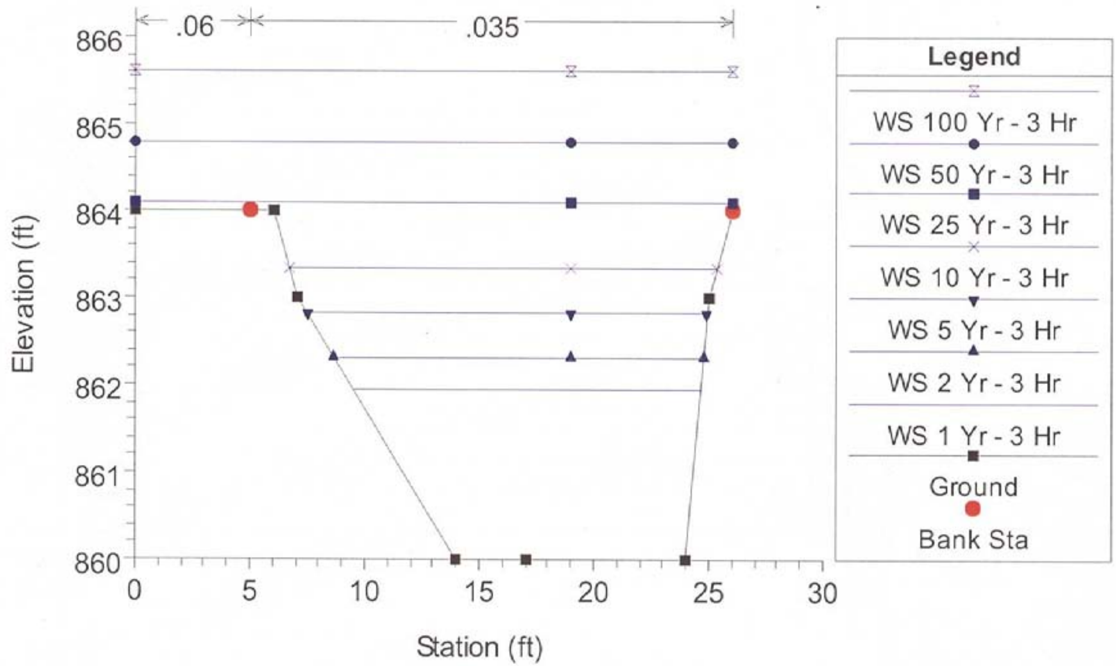
HARZA ENGINEERING COMPANY
WATER & ENVIRONMENT



LEELAND ADDITION CHANNEL WITH SHEETPILE DAM
LAKE WAWASEE ENGINEERING FEASIBILITY STUDY
Syracuse, Indiana

EXHIBIT 27

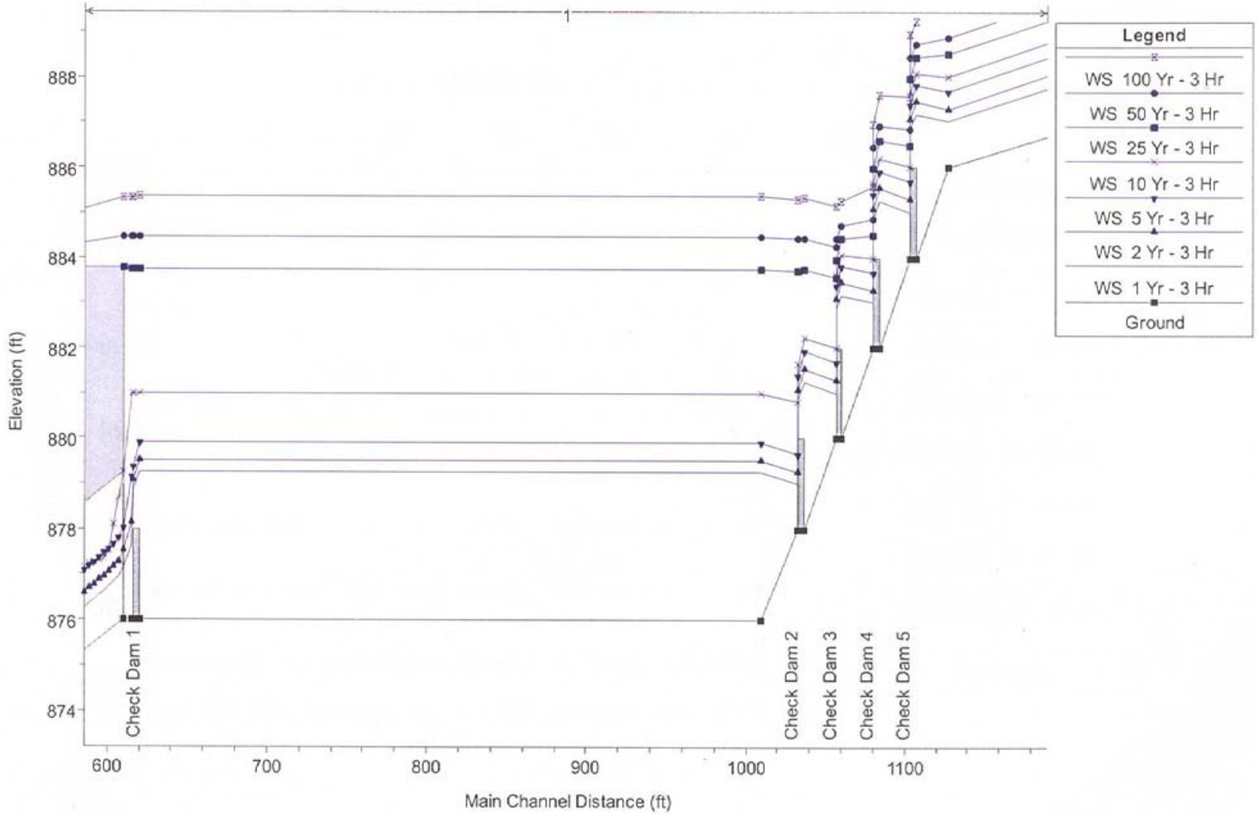
HARZA ENGINEERING COMPANY
WATER & ENVIRONMENT



HARZA ENGINEERING COMPANY
WATER & ENVIRONMENT

LEELAND ADDITION CHANNEL WITHOUT SHEETPILE DAM
LAKE WAWASEE ENGINEERING FEASIBILITY STUDY
Syracuse, Indiana

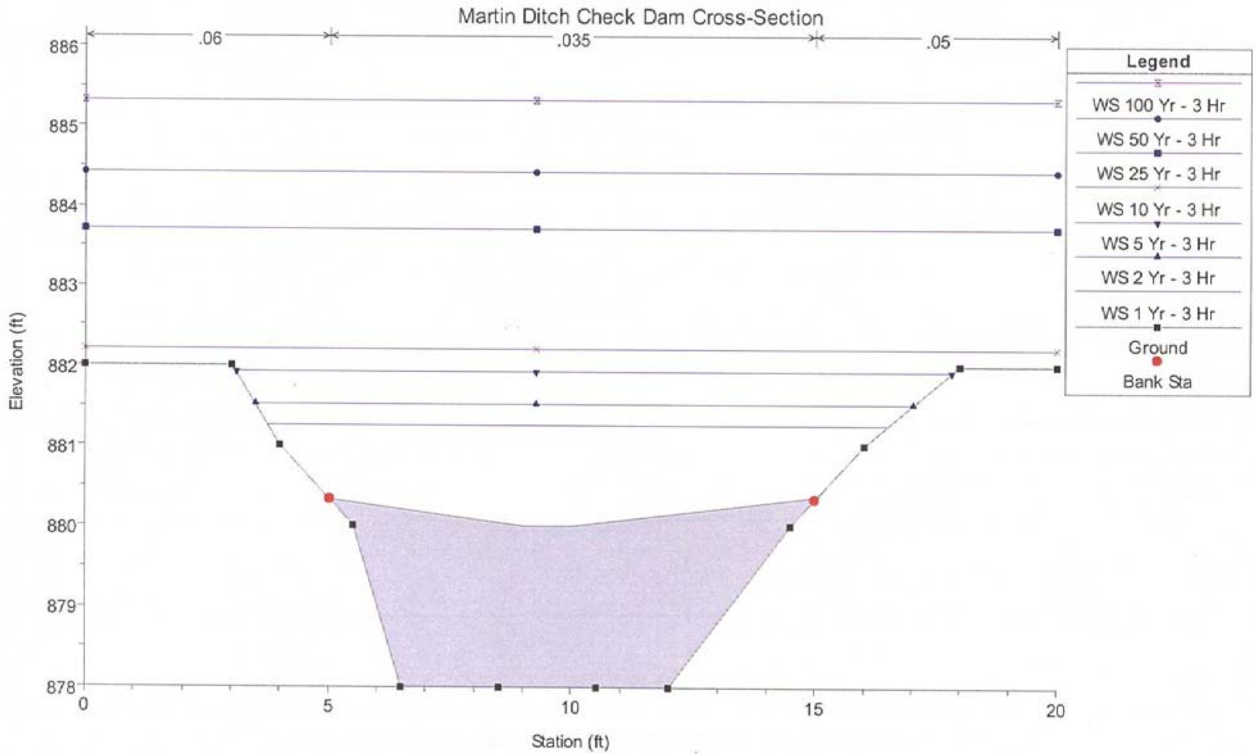
EXHIBIT 28



HARZA ENGINEERING COMPANY
WATER & ENVIRONMENT

MARTIN DITCH CHECK DAM PROFILE
LAKE WAWASEE ENGINEERING FEASIBILITY STUDY
Syracuse, Indiana

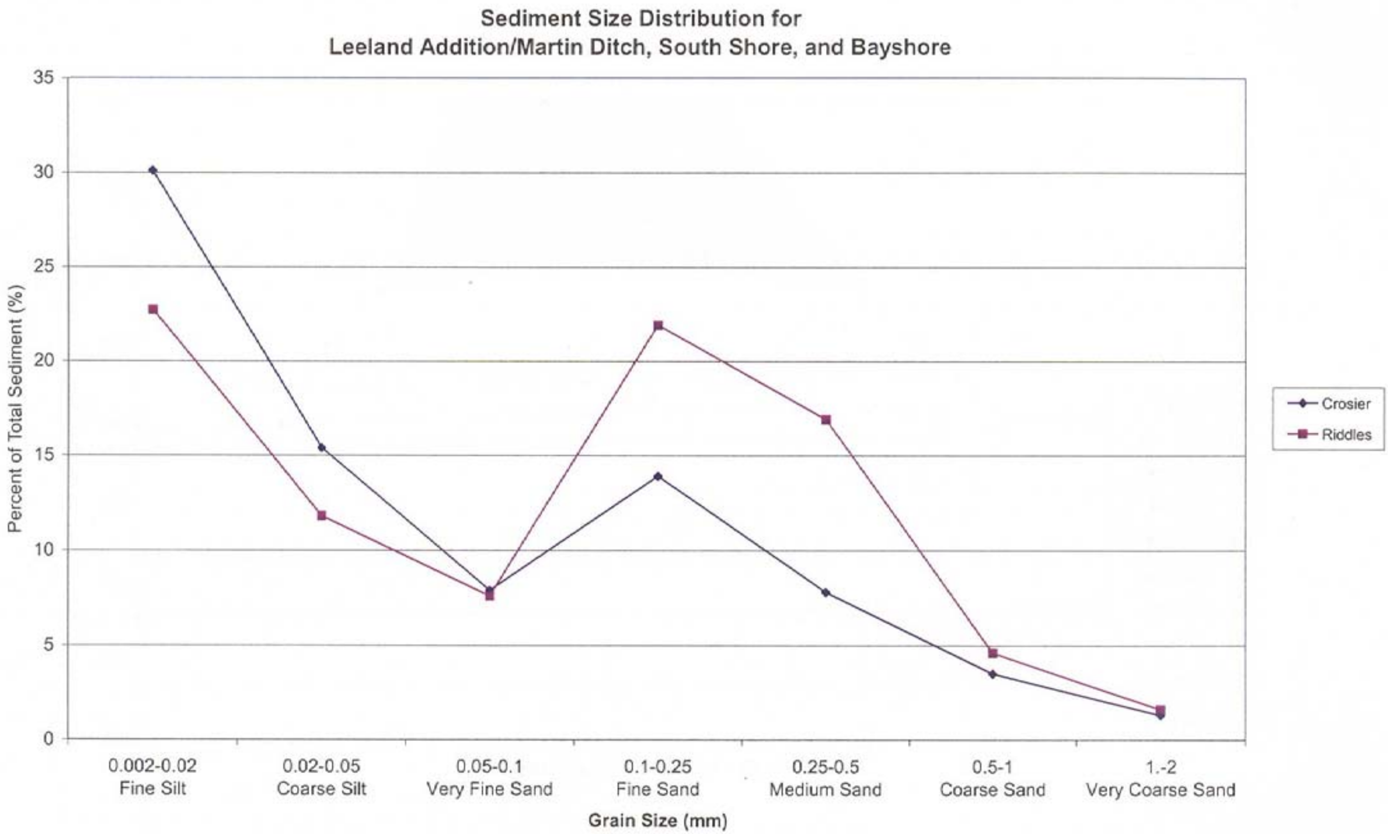
EXHIBIT 29



HARZA ENGINEERING COMPANY
WATER & ENVIRONMENT

MARTIN DITCH CHECK DAM CROSS SECTION
LAKE WAWASEE ENGINEERING FEASIBILITY STUDY
Syracuse, Indiana

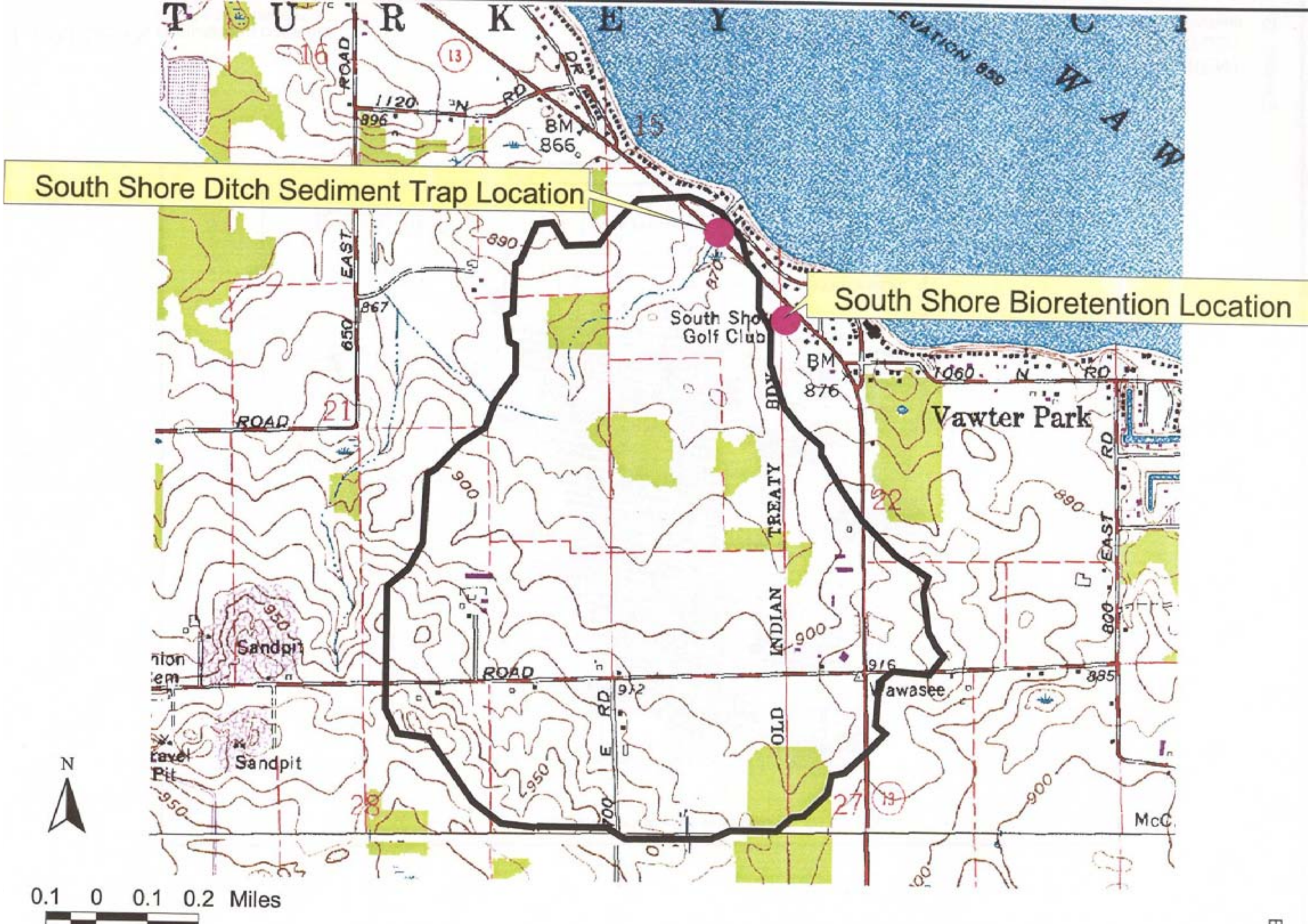
EXHIBIT 30



SEDIMENT SIZE DISTRIBUTION FOR
LELAND ADDITION/ MARTIN DITCH, SOUTH SHORE, AND BAYSHORE
LAKE WAWASEE ENGINEERING FEASIBILITY STUDY
Syracuse, Indiana

EXHIBIT 31

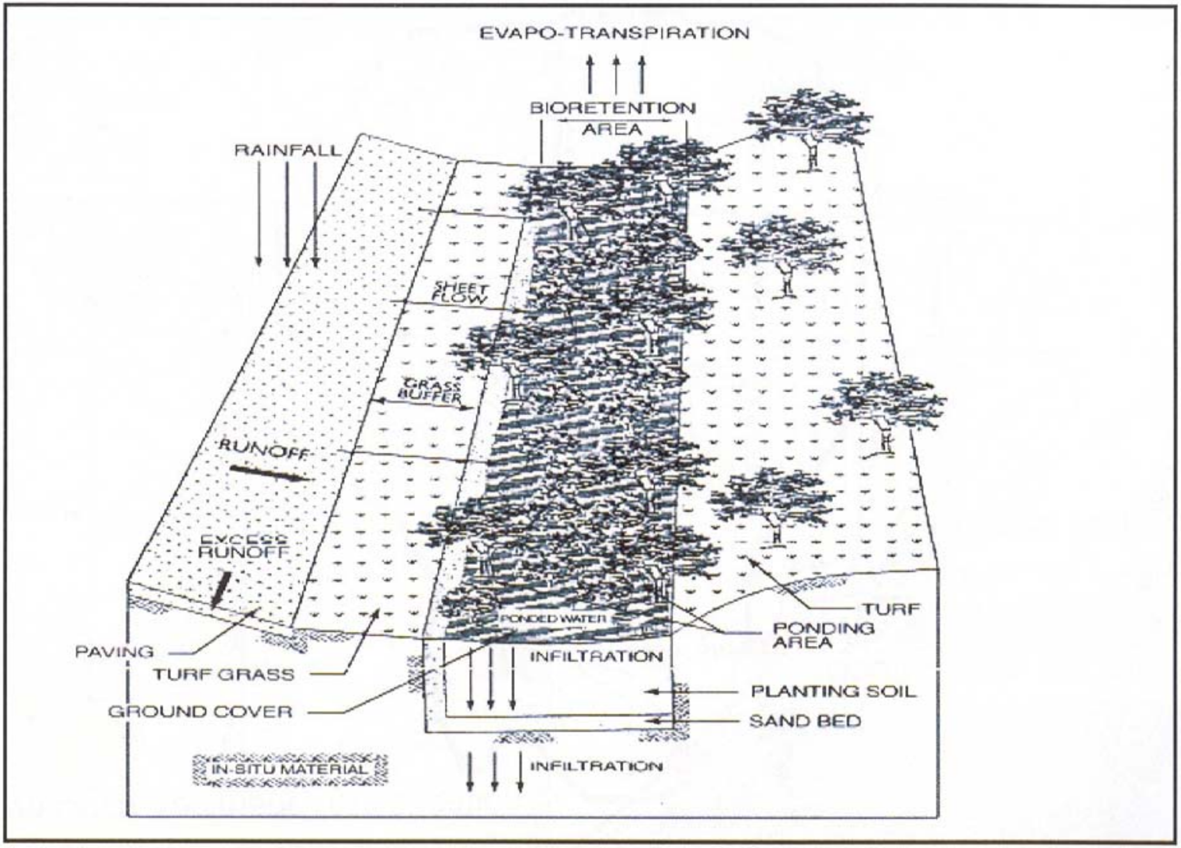
HARZA ENGINEERING COMPANY
WATER & ENVIRONMENT



HARZA ENGINEERING COMPANY
WATER & ENVIRONMENT

SOUTH SHORE AND WATERSHED AND PROJECT LOCATIONS
LAKE WAWASEE ENGINEERING FEASIBILITY STUDY
Syracuse, Indiana

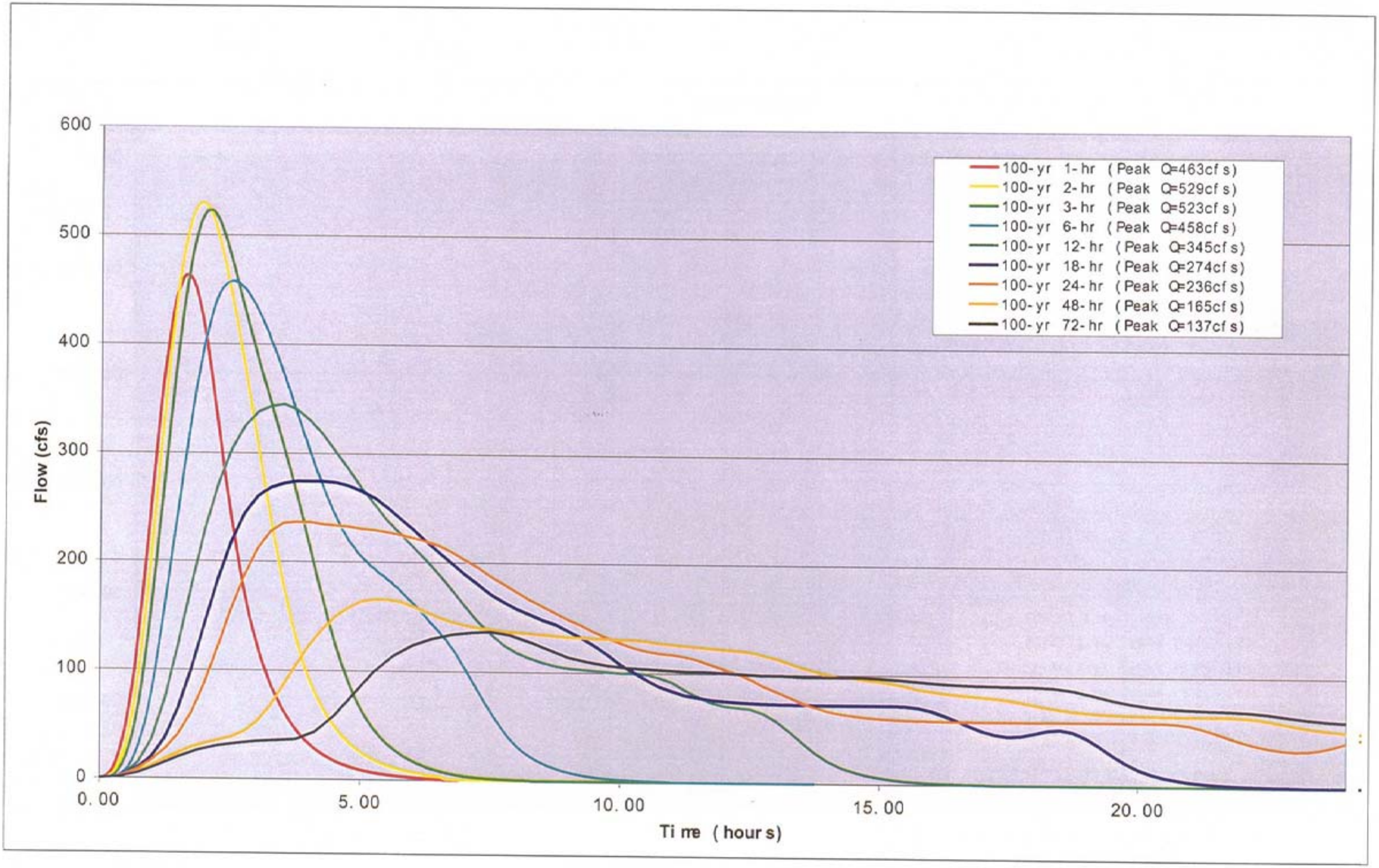
Exhibit 32



BIORETENTION TREATMENT
LAKE WAWASEE ENGINEERING FEASIBILITY STUDY
Syracuse, Indiana

EXHIBIT 33

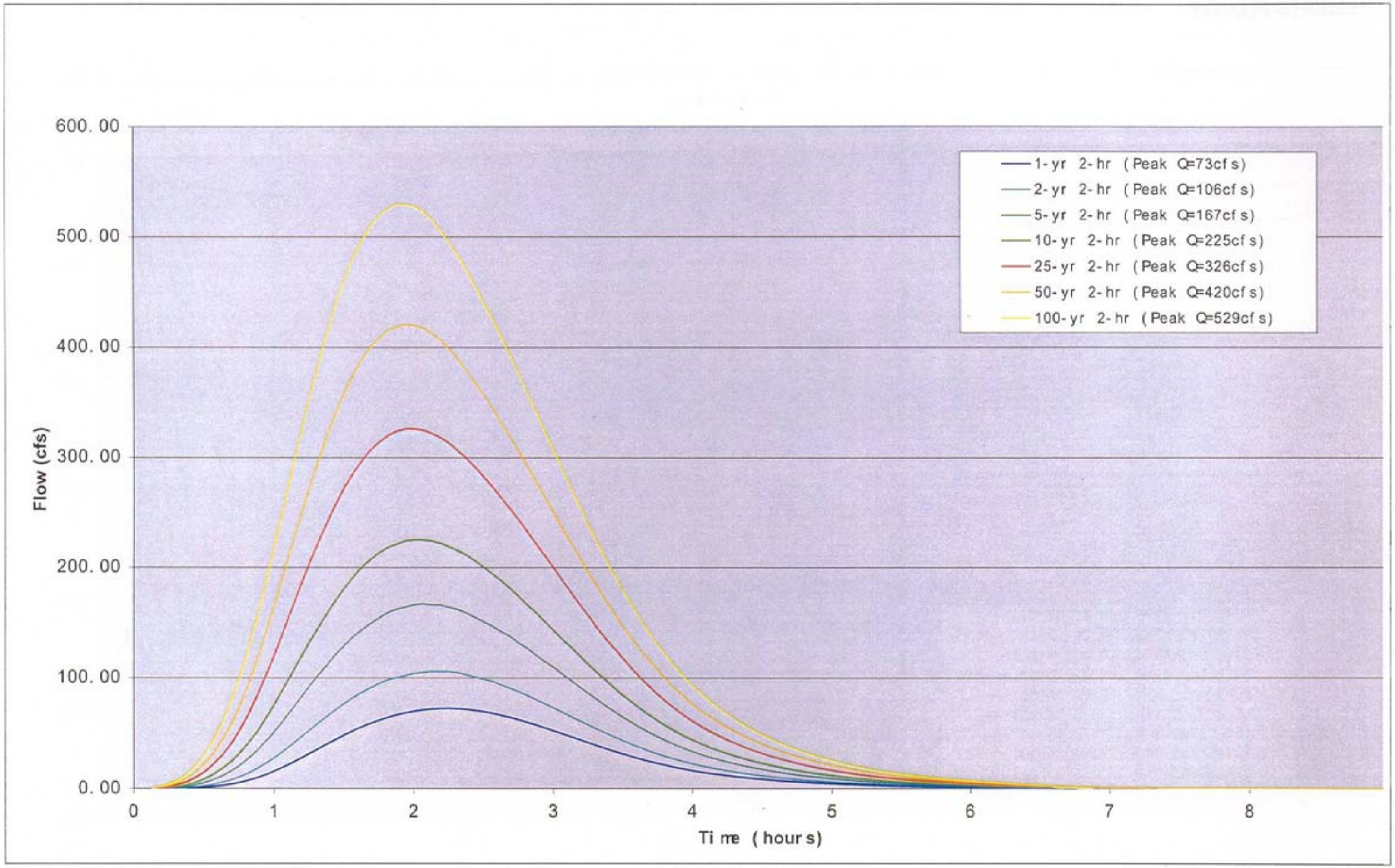
HARZA ENGINEERING COMPANY
WATER & ENVIRONMENT



HARZA ENGINEERING COMPANY
WATER & ENVIRONMENT

SOUTH SHORE
HYDROLOGIC SENSITIVITY ANALYSIS
LAKE WAWASEE ENGINEERING FEASIBILITY STUDY
Syracuse, Indiana

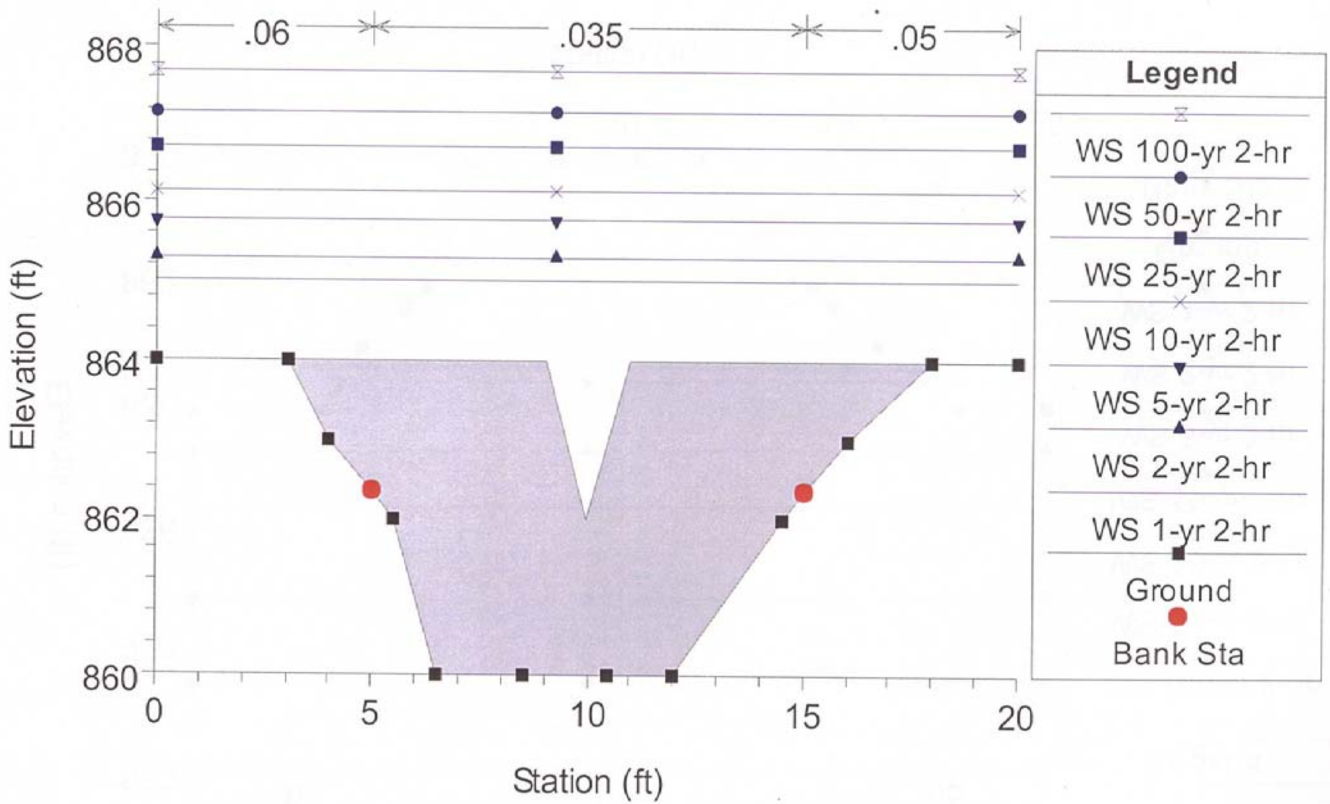
EXHIBIT 34



SOUTH SHORE
RUNOFF HYDROGRAPHS
LAKE WAWASEE ENGINEERING FEASIBILITY STUDY
Syracuse, Indiana

EXHIBIT 35

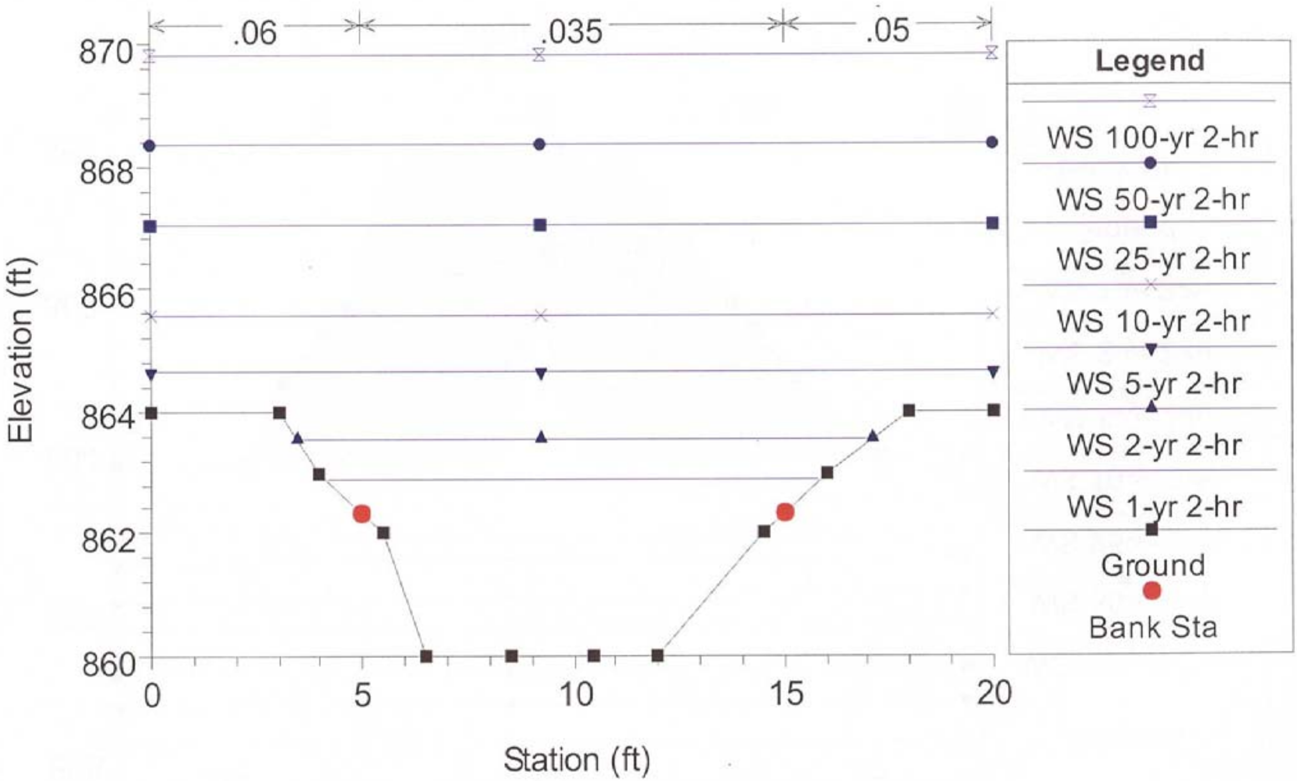
HARZA ENGINEERING COMPANY
WATER & ENVIRONMENT



HARZA ENGINEERING COMPANY
WATER & ENVIRONMENT

SOUTH SHORE DITCH WITH SHEETPILE DAM
LAKE WAWASEE ENGINEERING FEASIBILITY STUDY
Syracuse, Indiana

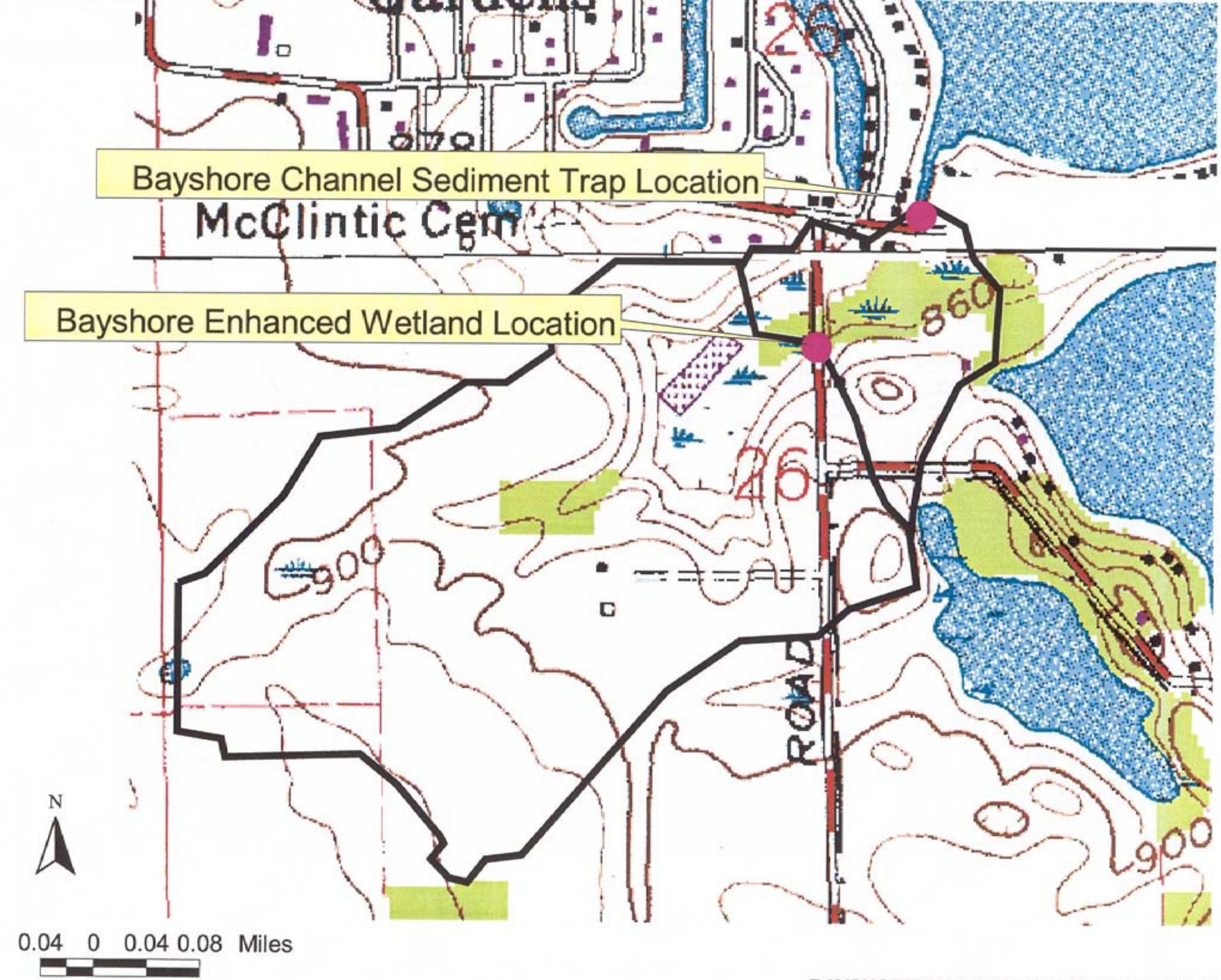
EXHIBIT 36



SOUTH SHORE DITCH WITHOUT SHEETPILE DAM
LAKE WAWASEE ENGINEERING FEASIBILITY STUDY
Syracuse, Indiana

EXHIBIT 37

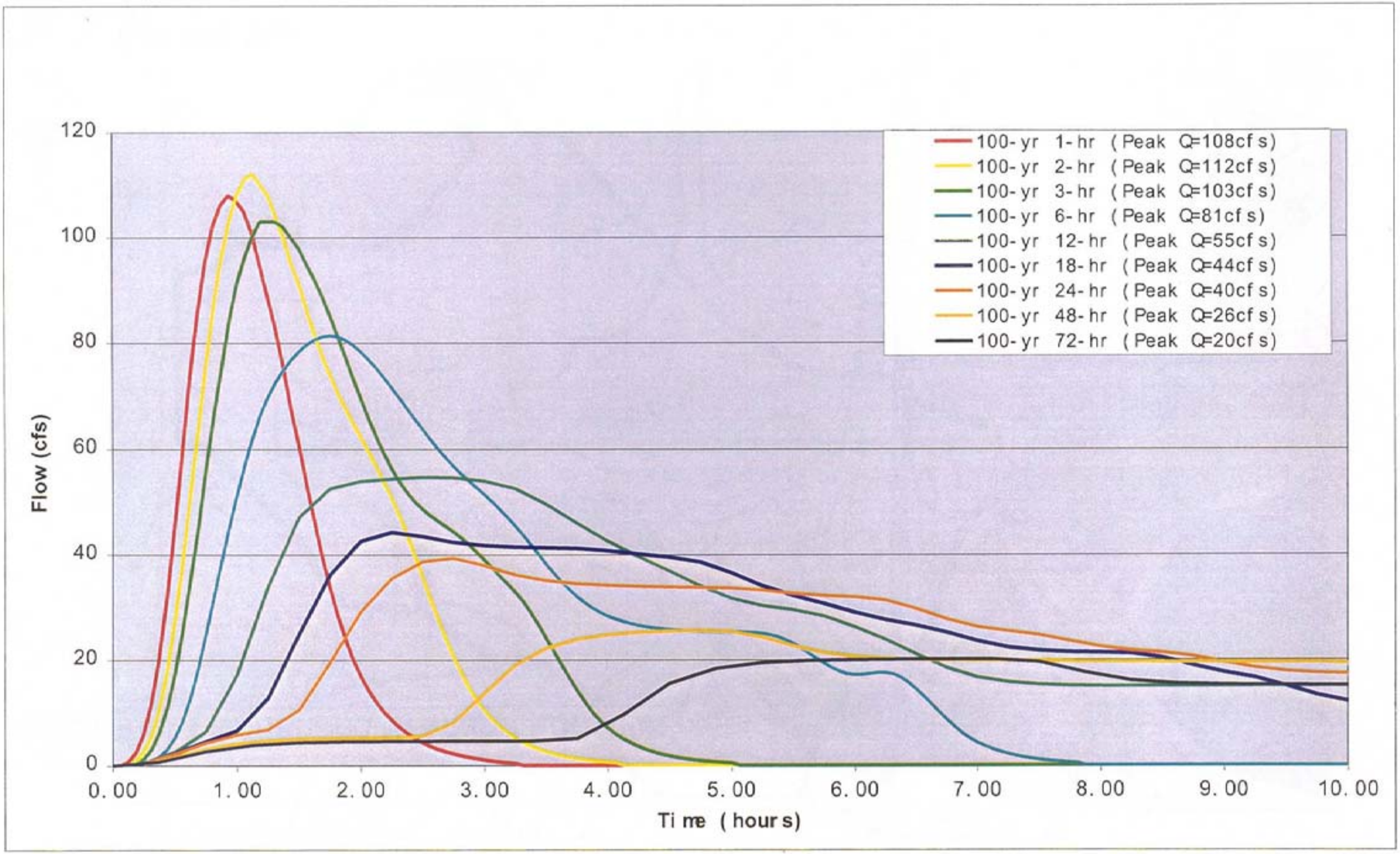
HARZA ENGINEERING COMPANY
WATER & ENVIRONMENT



HARZA ENGINEERING COMPANY
WATER & ENVIRONMENT

BAYSHORE WATERSHED AND PROJECT LOCATIONS
LAKE WAWASEE ENGINEERING FEASIBILITY STUDY
Syracuse, Indiana

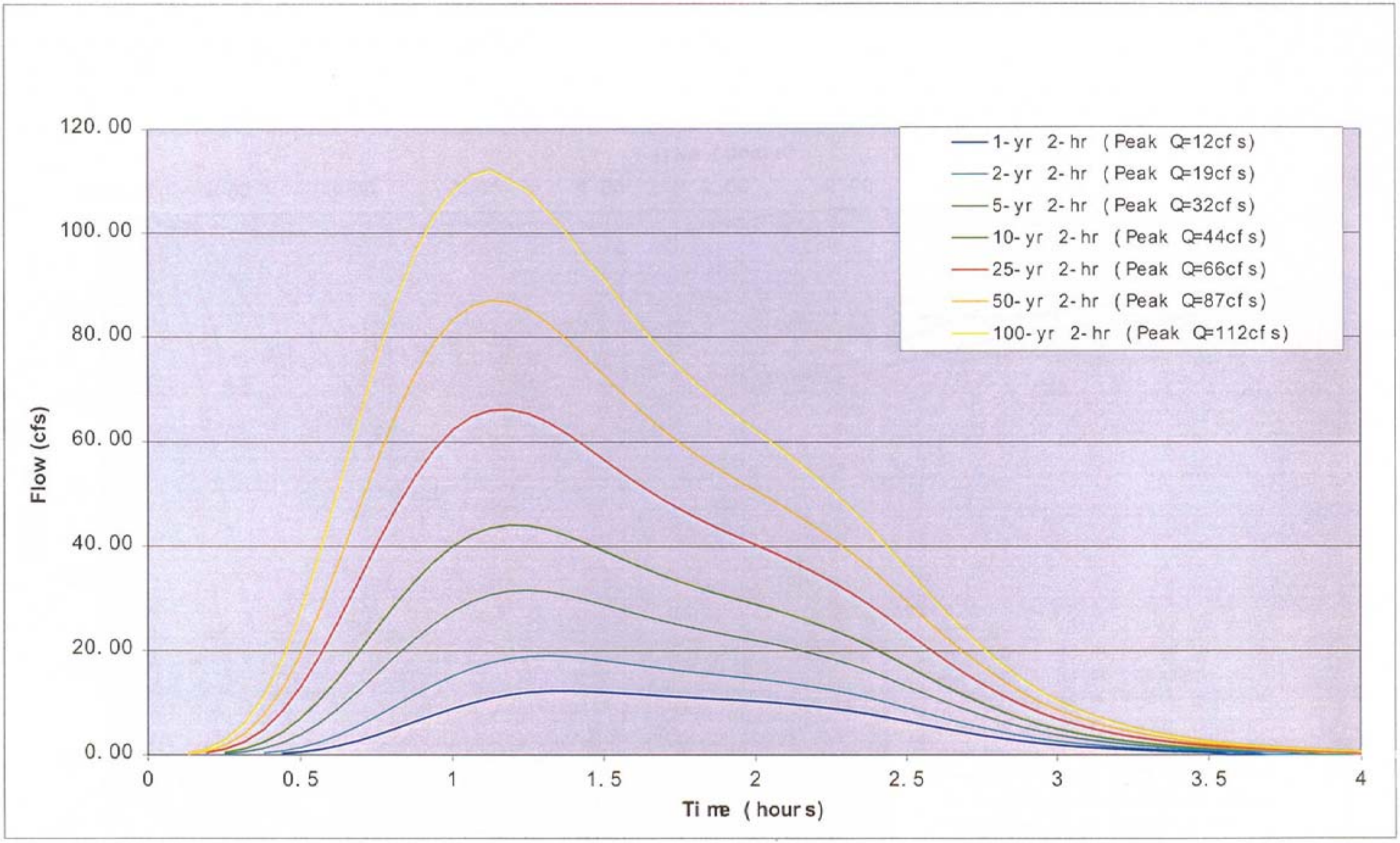
Exhibit 38



HARZA ENGINEERING COMPANY
WATER & ENVIRONMENT

BAYSHORE WETLAND HYDROLOGIC SENSITIVITY ANALYSIS
LAKE WAWASEE ENGINEERING FEASIBILITY STUDY
Syracuse, Indiana

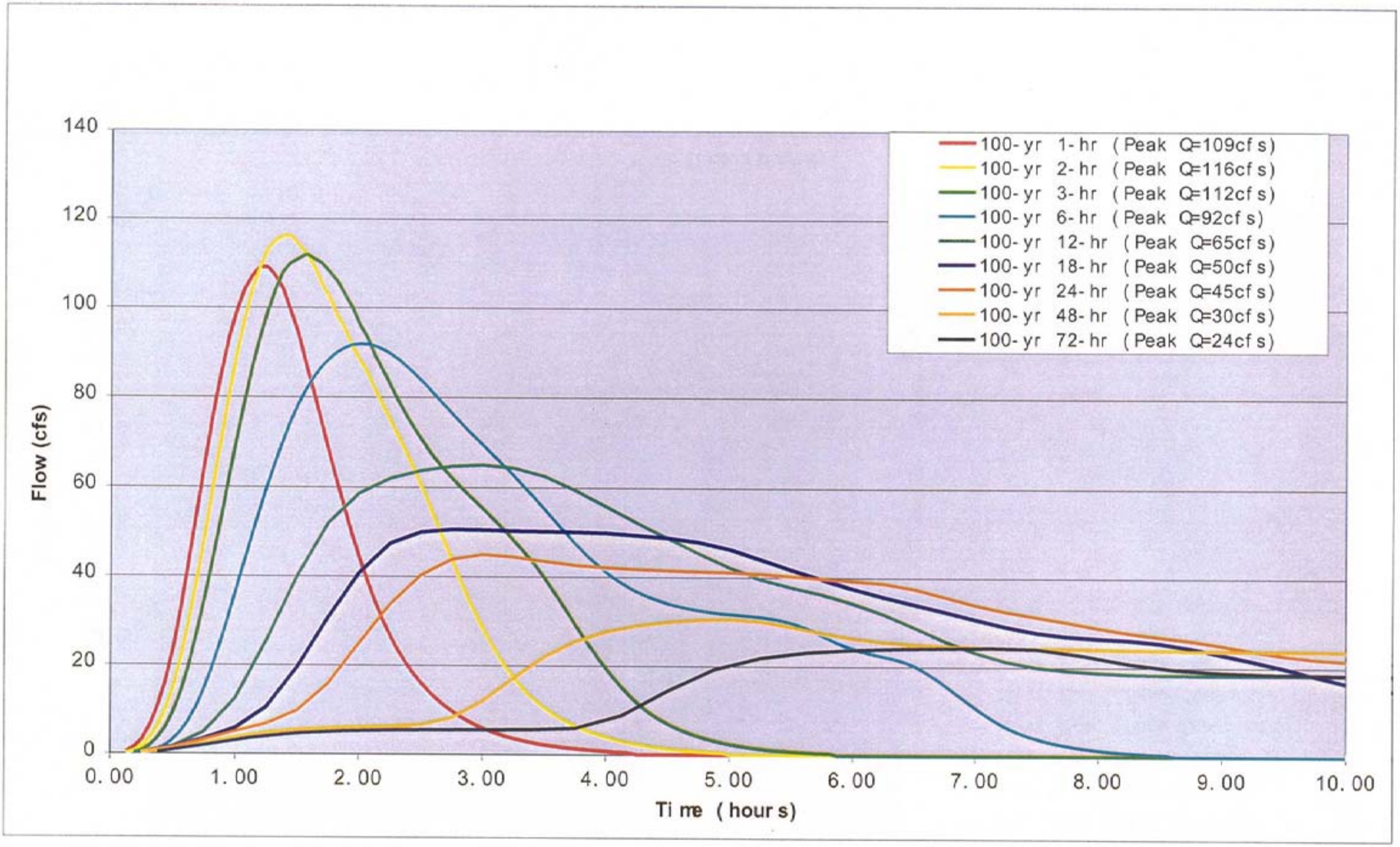
EXHIBIT 39



HARZA ENGINEERING COMPANY
WATER & ENVIRONMENT

BAYSHORE WETLAND RUNOFF HYDROGRAPHS
LAKE WAWASEE ENGINEERING FEASIBILITY STUDY
Syracuse, Indiana

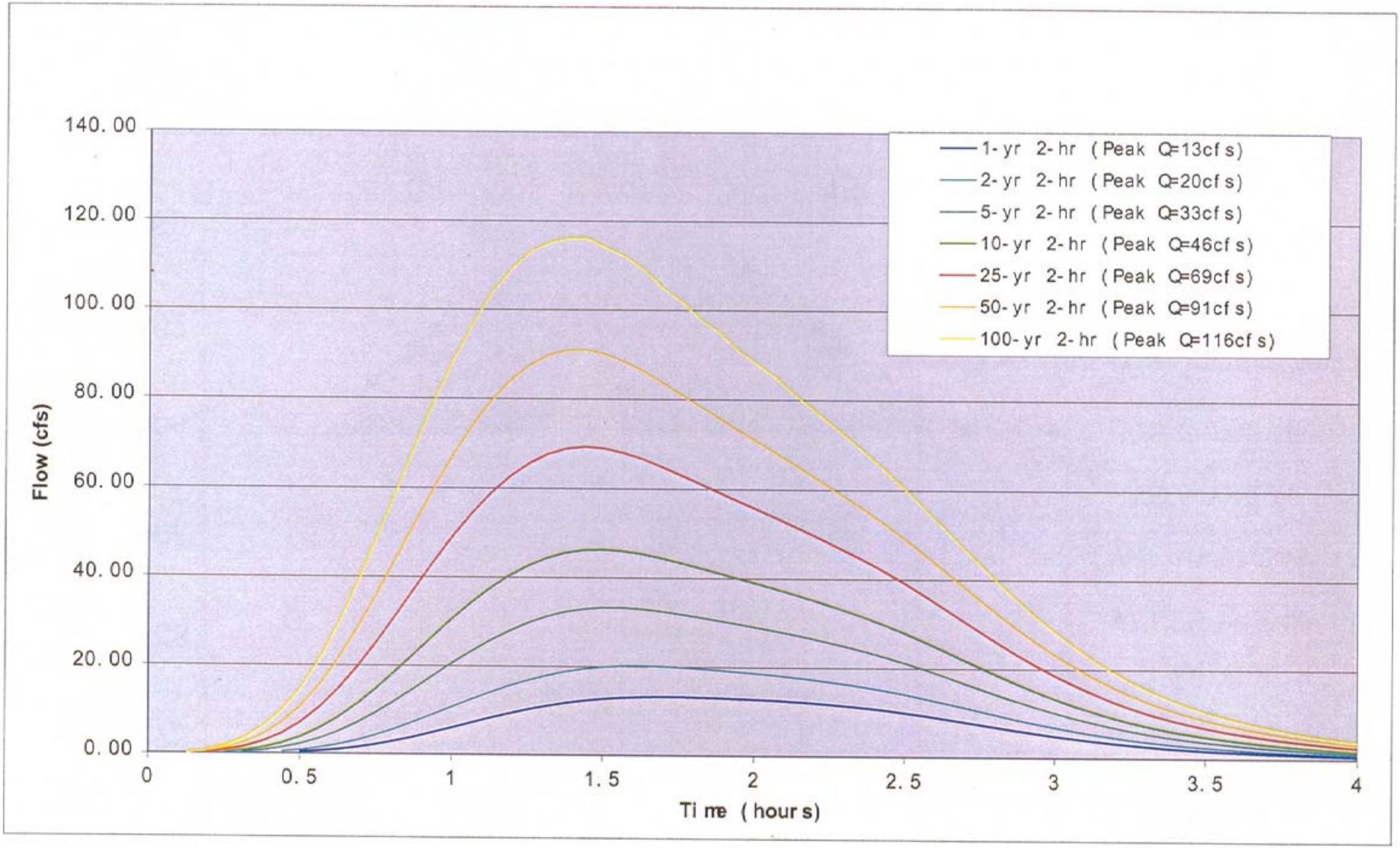
EXHIBIT 40



HARZA ENGINEERING COMPANY
WATER & ENVIRONMENT

BAYSHORE CHANNEL HYDROLOGIC SENSITIVITY ANALYSIS
LAKE WAWASEE ENGINEERING FEASIBILITY STUDY
Syracuse, Indiana

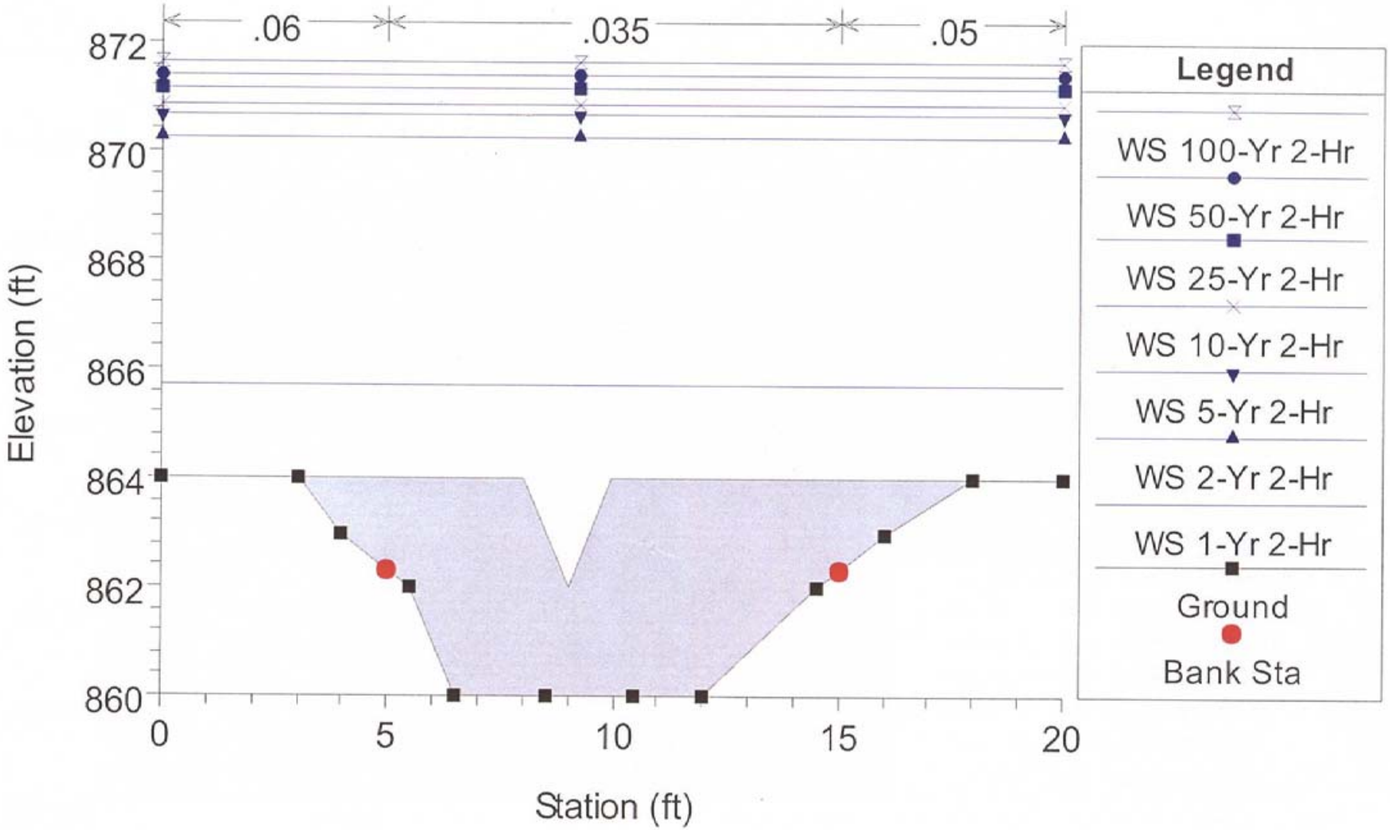
EXHIBIT 41



HARZA ENGINEERING COMPANY
WATER & ENVIRONMENT

BAYSHORE CHANNEL RUNOFF HYDROGRAPHS
LAKE WAWASEE ENGINEERING FEASIBILITY STUDY
Syracuse, Indiana

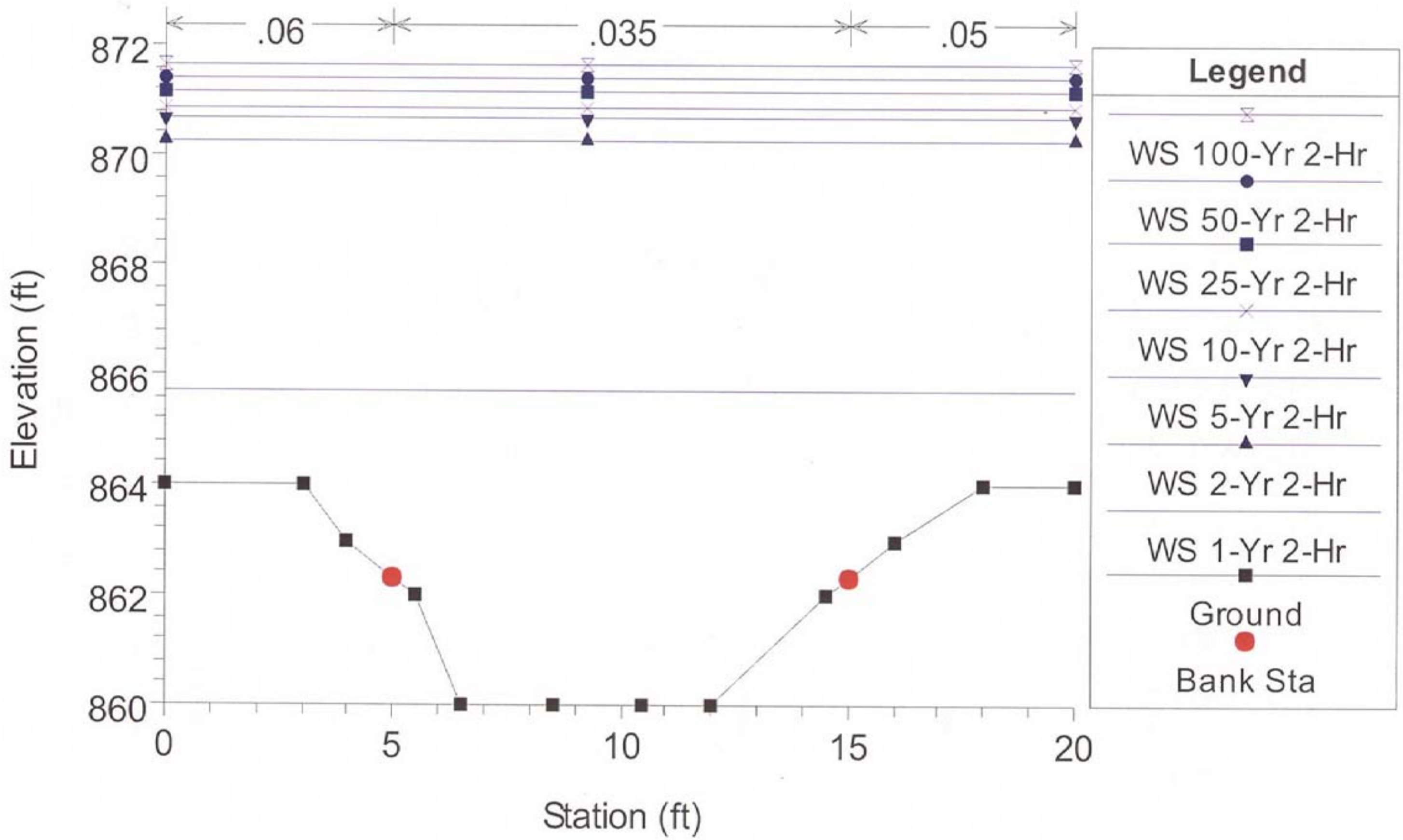
EXHIBIT 42



HARZA ENGINEERING COMPANY
WATER & ENVIRONMENT

BAYSHORE WETLAND WITH SHEETPILE DAM
LAKE WAWASEE ENGINEERING FEASIBILITY STUDY
Syracuse, Indiana

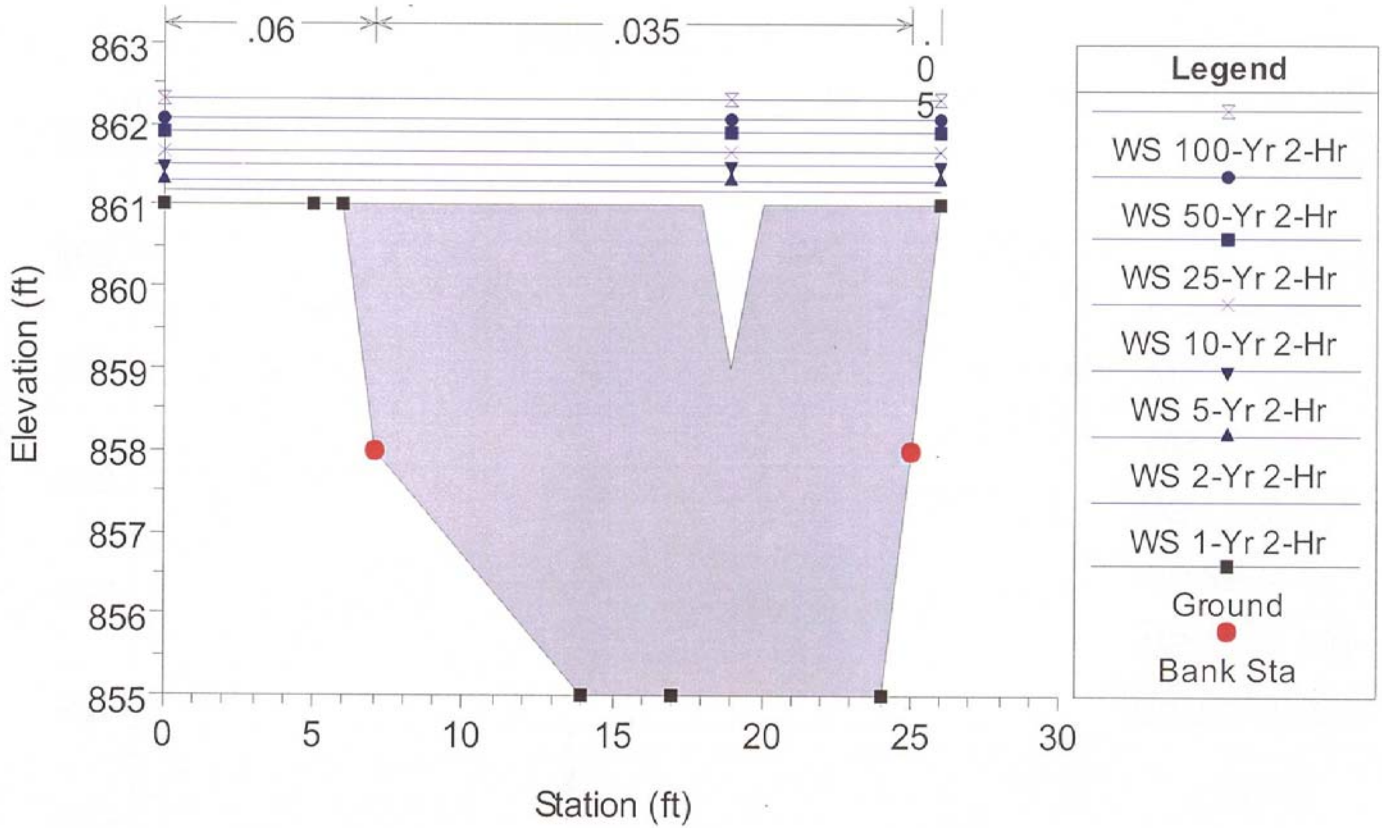
EXHIBIT 43



HARZA ENGINEERING COMPANY
WATER & ENVIRONMENT

BAYSHORE WETLAND WITHOUT SHEETPILE DAM
LAKE WAWASEE ENGINEERING FEASIBILITY STUDY
Syracuse, Indiana

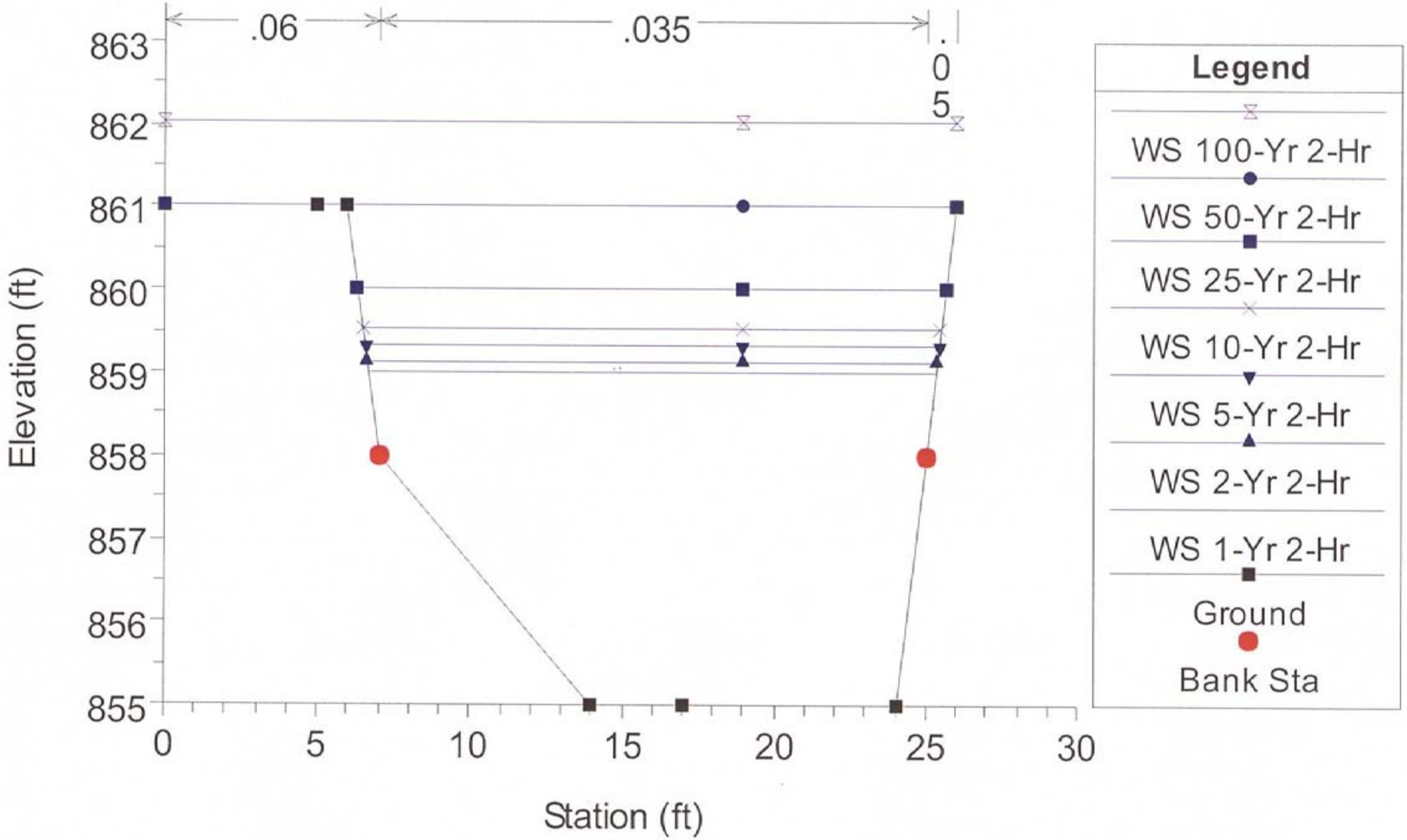
EXHIBIT 44



HARZA ENGINEERING COMPANY
WATER & ENVIRONMENT

BAYSHORE CHANNEL WITH SHEETPILE DAM
LAKE WAWASEE ENGINEERING FEASIBILITY STUDY
Syracuse, Indiana

EXHIBIT 45



HARZA ENGINEERING COMPANY
WATER & ENVIRONMENT

BAYSHORE CHANNEL WITHOUT SHEETPILE DAM
LAKE WAWASEE ENGINEERING FEASIBILITY STUDY
Syracuse, Indiana

EXHIBIT 46

Appendices Follow:

Appendix A: Site Selection Technical Memorandum

Appendix B: Sample Permit Applications

Appendix C: Enchanted Hills Property Owners

Appendix D: HEC-RAS Overview

Appendix E: Agricultural Best Management Practices

Appendix A: Site Selection Technical Memorandum

LAKE WAWASEE ENGINEERING FEASIBILITY STUDY

Identification of Potential Pollution Control Projects

This memorandum identifies watershed alternatives for improving water quality at Lake Wawasee, in Koscuisko County, Indiana. It documents Task 1 in the engineering feasibility study authorized by the Wawasee Area Conservancy Foundation (WACF) under their Lake and River Enhancement (LARE) grant.

After meeting with interested parties at the Lake Wawasee Engineering Feasibility Study Public Meeting #1 on August 30, 2000 and reviewing available historical data, the following improvement measures are reviewed herein, and recommendations are presented for full feasibility level evaluation.

Improvement 1:	Restoration of the original flow channel from the Enchanted Hills through Johnson Bay
Improvement 2:	Grade stabilization structures in Enchanted Hills subwatershed
Improvement 3:	Bank stabilization in Enchanted Hills subwatershed
Improvement 4:	Sediment trap and constructed wetland on Dillon Creek (Enchanted Hills)
Improvement 5:	Erosion control on development sites (e.g., Leeland Addition and South Shore)
Improvement 6:	Sediment traps and/or stormwater retention in the Leeland Addition (Martin Ditch) and South Shore subwatersheds
Improvement 7:	A reconstructed wetland in the Bayshore Swamp

Stormwater samples will be taken in the Bayshore, South Shore, and Dillon Creek Subwatersheds to gain further information on sediment and nutrients loadings at these locations. This data will be incorporated into the Engineering Feasibility Study as it becomes available.

Background Information

Background data on Lake Wawasee includes *Preliminary Investigation of the Lakes of Kosciusko County* (1989), *Enchanted Hills Watershed Evaluation* (1994), *Lake Enhancement Diagnostic/Feasibility Study for the Wawasee Area Watershed* (1995), and several letter reports focusing on specific areas around the lake. Located in Kosciusko County in northern Indiana, Lake Wawasee is Indiana's largest natural lake. The lake measures 3,400 acres and is a popular site for recreation and fishing. Runoff from the 23,918-acre watershed flows into Lake Wawasee through Turkey Creek, Papakeechie Lake, Bonar Lake, Dillon Creek/Enchanted Hills, and several smaller drainages. Lake Wawasee's watershed drains to the northwest to the St. Joseph River basin.

Lake Wawasee has historically exhibited high water quality, however during runoff events, plumes of sediment have been observed to enter the lake at several inlet areas. The 1995 Diagnostic/Feasibility report identified areas of the watershed in which improvements are necessary. These areas include the Enchanted Hills, South Shore, Bayshore, and Leeland Addition subwatersheds. The possible pollution control projects are detailed below.

Description of Improvements

Improvement 1: <u>Restoration of the Original Flow Channel from the Enchanted Hills through Johnson Bay</u>. When the Enchanted Hills subdivision was developed, Dillon Creek was diverted through the channels and into Lake Wawasee near Cedar Point. Previously, Dillon Creek flowed into Johnson Bay through the wetland system to the north and east of the bay. Possible water quality benefits of rerouting Dillon Creek through the Johnson Bay wetland include reduced sediment or nutrient load entering Lake Wawasee from the Dillon Creek/Enchanted Hills area due to slowing of the water in the wetland and plant uptake of nutrients, and greater flushing potential for the Enchanted Hills channels. Several options for this improvement include:

- Creating a stream channel connecting the northernmost channel in Enchanted Hills to the Johnson Bay wetland;
- Connecting the westernmost channel in Enchanted Hills to the Johnson Bay wetland via the original flowpath; and
- Diverting Dillon Creek around the Enchanted Hills channels to the Johnson Bay wetland.

Hydrologic investigations will be required to ensure that water levels in the lake and the channels would support a connection to the Johnson Bay wetland. In order for this alternative to be implemented, it will require permits from the U.S. Army Corp of Engineers and Indiana DNR Division of Water. Other concerns include easement availability, road and utility crossings, and topography. Possible negative effects include loss or modification of wetland habitat and disruption or destruction of natural hydrology and detention capabilities. We consider the potential adverse effects on the Johnson Bay wetland to be significant.

Johnson Bay Wetland Characterization

Harza reconnoitered vegetation communities in Johnson Bay. Dominant species are listed in Table 1. No endangered, threatened or rare species were found. Obligate wetland species, facultative wetland species, facultative upland species and upland species were found there, testifying to the variety of habitats and hydrologic regimes present. We characterize the Johnson Bay wetland as a freshwater marsh, with emergent aquatic plants growing in a permanent to seasonal shallow water. Scrub-shrub wetland communities exist both within and bordering the emergent community.

Table 1

JOHNSON BAY WETLANDS DOMINANT VEGETATION SPECIES

Common Name	**Latin Name**	**Wetland Indicator Category**
Broad-Leaved Arrowhead	*Sagittaria latifolia*	OBL aquatic - emergent
Pond Lilly	*Nuphar lutea*	OBL aquatic - emergent
Water Lilly	*Nymphaea odorata*	OBL aquatic - emergent
Water Shield	*Brasenia schreberi*	OBL aquatic - emergent
Narrow-Leaf Cattail	*Typha angustifolia*	OBL
Buckbean	*Menyanthes trifoliata*	OBL
Marsh Fern	*Thelypteris thelypteroides*	FACW+
Spotted Touch-Me-Not	*Impatiens capensis*	FACW
Nuttall's Waterhemp	*Amaranthus rudis*	FACW
Sensitive Fern	*Onoclea sensibilis*	FACW
Silver Maple	*Acer saccharinum*	FACW
Green Ash	*Fraxinus pennsylvanica*	FACW
Red-Osier Dogwood	*Cornus stolonifera*	FACW
River-Bank Grape	*Vitis riparia*	FACW-
Eastern Cottonwood	*Populus deltoides*	FAC+
Smooth Rose	*Rosa blanda*	FACU
Black Walnut	*Juglans nigra*	FACU

Key: OBL = obligate wetland species; probability of occurrence in wetlands: > 99%
FACW+ = facultative wetland species; probability of occurrence in wetlands: 51 to 66%
FACW- = facultative wetland species; probability of occurrence in wetlands: 34 to 50%
FACU+ = facultative upland species; probability of occurrence in wetlands: 17 to 33%
FACU- = facultative upland species; probability of occurrence in wetlands: 1 to 16%
UPL = upland species; probability of occurrence in wetlands: <1%

Recommendations

Table 2 outlines the benefits and disadvantages of each alternative for the restoration of the original flow channel from Enchanted Hills through Johnson Bay.

Table 2

SUMMARY OF BENEFITS AND DISADVANTAGES OF RESTORATION OF THE ORIGINAL FLOW CHANNEL FROM ENCHANTED HILLS THROUGH JOHNSON BAY

Options	Benefits	Disadvantages
Connecting Northernmost Channel to Johnson Bay Wetland	-Close proximity to wetland, least construction disruption and cost -Create flushing in the channels -Water quality improvement via wetland	-Possible negative impacts to Johnson Bay wetland -Land and permits -Road crossings and easements -Hydrologic alteration of lake/channel water interaction
Connecting Westernmost Channel to Original Flowpath of Dillon Creek and into Johnson Bay Wetland	-Somewhat close proximity to wetland, moderate construction disruption and cost -Create flushing in the channels -Water quality improvement via wetland	-Possible negative impacts to Johnson Bay wetland -Land and permits -Road crossings and easements -Hydrologic alteration of lake/channel water interaction
Diverting Dillon Creek around Channels to Johnson Bay Wetland	-Restoring Dillon Creek to natural function -Water quality improvement in Dillon Creek via wetland	-Possible negative impacts to Johnson Bay wetland -Land and permits -Road crossings and easements -Reduce minor flushing effect of Dillon Creek in channels -Stream crossings -Major channel relocation, high construction disruption and cost

Our recommendation at this time is to proceed with the engineering feasibility study on the option of connecting the westernmost channel to the Johnson Bay wetland and on the option of connecting the northernmost channel to the Johnson Bay wetland.

Improvements 2 and 3: Grade and Bank Stabilization in the Enchanted Hills Subwatershed. The Enchanted Hills subdivision consists of homes (some atop steeply graded hills) abutting channels. The channel slopes throughout the subdivision are eroding and are sources of sediment for Lake Wawasee. Large sediment plumes have been observed at the inlet to the lake. Harza performed a lot-by-lot assessment of the subdivision to identify areas in need of bank and grade stabilization (Figure 1). We characterized erosion as "severe" (unprotected with moderate to steep slopes, some vegetation, and severe erosion), "moderate" (unprotected with moderate to steep slopes, vegetation, and moderate erosion), "slight" (unprotected with gentle slopes, vegetated, and moderate erosion) and "potential" (unprotected with gentle to steep slopes, vegetated, and no current erosion). Shoreline categorized as "severe" totaled approximately 5,310 lineal feet, areas categorized as "moderate" totaled approximately 2,145 lineal feet, areas categorized as "slight" totaled approximately 2,670 lineal feet, and areas of categorized as "potential" totaled approximately 4,269 lineal feet.

Various types of erosion control are available, including fiber rolls, emergent and herbaceous plantings, sheetpiling, concrete seawall, and boulders and stone. Several homeowners have already implemented these techniques in the Enchanted Hills subdivision. Costs of these treatments range from approximately $125 to $200 per linear foot (based on cost estimates taken from diagnostic/feasibility study of The Morton Arboretum Lakes, Harza 2000). Treatments such as fiber rolls, and emergent and herbaceous plantings will require some maintenance and may not be completely effective in areas of high wave/wake energy. Installation of sheetpiling or concrete seawall would reduce natural habitat along the shoreline. For all options, there may be homeowner resistance to the use of their land for this purpose.

Recommendations

Table 3 outlines the benefits and disadvantages of each alternative for the grade and bank stabilization measures for the Enchanted Hills watershed.

Table 3

SUMMARY OF BENEFITS AND DISADVANTAGES OF GRADE AND BANK STABILIZATION IN THE ENCHANTED HILLS SUBWATERSHED

Options	Benefits	Disadvantages
Fiber Rolls with Plantings	-Provides natural habitat -Medium cost, ~\$120-\$170/ft -Proven effective in demonstration project	-May not be effective in areas of high wave/wake energy -Need some watering & maintenance -Possible homeowner resistance
Emergent Plantings	-Provides natural habitat -Low cost, ~ less than \$120/ft	-May not be effective in areas of high wave/wake energy -Possible homeowner resistance
Herbaceous Plantings	-Provides natural habitat -Low cost, ~ less than \$120/ft	-May not be effective in areas of high wave/wake energy -Need some watering & maintenance -Possible homeowner resistance
Sheetpiling	-Protection from wave/wake energy -Low maintenance	-High cost, ~\$190/ft -Loss of habitat -Possible homeowner resistance
Concrete Seawall	-Protection from wave/wake energy -Low maintenance	-High cost -Loss of habitat -Possible homeowner resistance
Boulders and Stone	-Protection from wave/wake energy -Low maintenance -Natural-looking -Provides habitat	-High cost, ~\$190/ft -Possible homeowner resistance

We recommend that the areas of severe erosion be the initial focus of the grade and bank stabilization improvements, with the highest priority given to shoreline that takes the most wave/wake energy (i.e. entrance to channels from Lake Wawasee, and channel intersections).

Each area of severe erosion will be evaluated for the most appropriate bank stabilization measure.

Improvement 4: Sediment Trap/Constructed Wetland on Dillon Creek (Enchanted Hills). This alternative would provide for increased detention and water quality treatment upstream of Enchanted Hills on Dillon Creek. Reducing flow rates and volumes and increasing detention time would lead to greater sedimentation and nutrient removal. A sediment trap, consisting of a settling basin with a sheetpile dam, is one alternative for Dillon Creek. A constructed wetland, consisting of a settling basin, sheetpile dam, and shallow pool with wetland vegetation, is another alternative. Both the sediment trap and constructed wetland require regular sediment removal and maintenance.

Three sites on Dillon Creek, DC1, DC2, and DC3, were evaluated for biological integrity and water quality. All three sites showed comparable biological characteristics, and are characterized as forested wetlands.

Dillon Creek Bioassessments

Harza used standard environmental assessment tools to characterize three potential BMP sites on Dillon Creek. Physical habitat was evaluated utilizing the Ohio EPA's Qualitative Habitat Evaluation Index (OEPA 1989). The benthic community was characterized using the EPA's Rapid Bioassessment Protocol II (EPA 1999).

In the application of the QHEI, a 300-foot section of each site was inspected by a two-person field team. During the evaluation, habitat scores are recorded for seven physical habitat metrics and the results are summed. These qualitative parameters include: substrate, instream cover, channel morphology, riparian zone and bank erosion, pool and glide quality, riffle and run quality, and gradient. QHEI reflects the quality of stream physical habitat. In this procedure, the highest scores are assigned to the habitat parameters that have been shown to be correlated with streams having high biological diversity and biological integrity. Progressively lower scores are assigned to less desirable habitat features.

Tables 4 through 6 show the results of our habitat surveys. Discharge was measured using a marsh-McBirney flow meter. Water quality was measured using a Yellow Springs Data Sonde. Interestingly, the low dissolved oxygen concentrations at DC 2, which are below the state standard of 5 mg/L, are likely due to the low flows and natural organic loading conditions.

Table 4

STREAM DISCHARGES FROM SEPTEMBER 2000

Site	Water body	Date	Discharge (ft^3/sec)
DC1	Dillon Creek	9/10/00	0.47
DC2	Dillon Creek	9/10/00	0.24
DC3	Dillon Creek	9/10/00	0.29

Table 5

IN-SITU WATER QUALITY RESULTS SEPTEMBER 2000

Site	Water	Temp (C)	Conductivity (umhos)	pH	DO (mg/L)
DC1	Dillon Creek	19.0	452	7.40	8.00
DC2	Dillon Creek	16.5	680	6.78	3.55
DC3	Dillon Creek	16.5	625	7.68	7.75

The QHEI results indicate that physical habitat quality at the three potential sites is similar. Riparian and channel habitat quality at DC was rated highest among the three sites, so we recommend minimal disruption of the area for construction. The substrate score at DC2 is the lowest as it is a natural depositional area.

Table 6

QUALITATIVE HABITAT EVALUATION INDEX

Site	Water body	Substrate	Cover	Channel	Riparian	Pool	Riffle	Gradient	QHEI
DC1	Dillon Creek	9	7	7	14	4	0	10	51
DC2	Dillon Creek	4	12	13	17	1	0	10	57
DC3	Dillon Creek	14	14	10	8	5	0	10	61

The US EPA's Rapid Bioassessment Protocol II (RBP II) utilizes the systematic field collection and analysis of major benthic taxa. This protocol is appropriate for prioritizing sites for watershed management projects. RBP II involves benthic analysis at the family taxonomic level. The technique utilizes field sorting and identification. The biological survey component of RBP II focuses on standardized sampling of benthic macroinvertebrates, supplemented by a cursory field observation of other aquatic biota such as periphyton, macrophytes, slimes and fish. The collection procedure provides representative samples of the macroinvertebrate fauna from riffle and run habitat types, and is supplemented with separate Course Particulate Organic Matter (CPOM) samples for the analysis of shredders and nonshredders. RBP II focuses on the riffle/run habitat because it is the most productive habitat available in stream systems and includes many pollution-sensitive taxa of the scraper and filtering collector functional feeding groups.

Collection of macroinvertebrates included quantitative and qualitative sampling methods. Quantitative sampling included triplicate sampling with a Surber sampler in riffles and runs. Qualitative sampling included rock picking for clinging individuals and netting individuals swimming within the water column. CPOM was collected from available detritus, leaves and sticks and individuals were counted until at least 50 individuals were obtained to evaluate the ratio of shredders to the total number of individuals collected.

Metrics used in the RBP indices evaluate aspects of elements and processes within the macroinvertebrate community. The indices do not incorporate metrics on individual condition, as is done with the fish-based Index of Biotic Integrity. The metrics in RBP II are taxa richness, Family Biotic Index, ratio of scrapers to filterers, ratio of EPT (Ephemeroptera, Plecoptera and Tricoptera) to Chironomidae, % contribution of dominant family, EPT index, ratio of shredders to nonshredders, and total individuals collected.

Table 7

MACROINVERTEBRATE RBP SCORES

Site	Taxa Richness	Family Biotic Index	Ratio of Scraper/ Filterer	Ratio of EPT/ Chironomidae	% Contribution Dominant Family	EPT Index	Ratio of Shredder/ Nonshredder	Total Number Collected
DC1	20	5.0	0.16	2.2	0.40	3	0.040	122
DC2	12	5.5	(45/0)	(3/0)	0.37	1	(0/50)	103
DC3	12	5.6	3.9	0.77	0.30	2	(0/50)	105

Taxa Richness is the total number of families present and represents biodiversity. Increasing diversity generally indicates with increasing health of the community and suggests that niche space, habitat, and food sources are adequate to support many species. This value generally increases with increasing water quality, habitat diversity and habitat suitability, and DC1 clearly has greater richness than the other two sites.

Modified Family Biotic Index (FBI) was developed to detect organic pollution and is a product of pollution tolerance values for family levels and the quantity of individuals within each family. Pollution tolerance values range from 0 to 10 for families and increase as water quality decreases. Again, the data suggest that the community present at DC1 is the least tolerant of pollution.

Feeding guilds of macroinvertebrates are enumerated in the RBP and used in two metrics. The ratio of the scrapers to filtering collectors reflects the riffle/run community food base. The relative abundance of scrapers and filtering collectors in the riffle/run habitat is indicative of periphyton community composition, availability of fine particulate organic material and the availability of attachment sites for filtering. Scrapers increase with an increase in diatom abundance and decrease in filamentous algae and aquatic mosses. Filamentous algae and aquatic mosses provide good attachment sites for filtering collectors and the organic enrichment often responsible for filamentous algae growth can also provide fine particulate organic material that is utilized by filtering collectors. Filtering collectors are also sensitive to toxicants bound to fine particles and should be the first group to decrease when exposed to steady sources of such bound toxicants. Dramatically differing scores in this metric were found between DC1 and DC2. No filters were found at DC2, but 45 scrapers were present.

The ratio of EPT (Ephemeroptera-mayflies, Plecoptera-stoneflies and Trichoptera-caddisflies) to Chironomidae (midges) are an indicator of good biotic condition if the sensitive groups (EPT's) demonstrate a substantial representation. If the Chironomidae have a disproportionately large number of individuals in comparison to the sensitive groups then environmental stress is indicated. Site DC3 had the poorest score in this category.

Percent Contribution of Dominant Family uses the abundance of the numerically dominant taxon relative to the total number of organisms as an indication of community balance at the family level. Scores in this category were similar for the three sites.

EPT Index value summarizes the taxa richness within the groups that are considered pollution sensitive and will generally increase with increasing water quality. This metric is the total number of distinct taxa within the groups Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies). Scores were fairly similar, with DC1 having 3 EPT, the highest score among the sites.

The ratio of the shredder functional feeding group relative to the abundance of all other functional feeding groups also allows for the evaluation of potential impairment. Shredders are sensitive to riparian zone impacts and are particularly good indicators of toxic effects when the toxicants involved are readily adsorbed to the CPOM and either affect microbial communities colonizing the CPOM or the shredders directly. Scores were similar among sites.

From the available data, it appears that site DC1 has the highest quality benthic community. DC1 has the richest fauna and the most pollution-sensitive species.

Site DC1

Constructing a wetland or sediment trap at site DC1 would remove sediment from the entire drainage of Dillon Creek prior to its discharge into the Enchanted Hills channels. Site DC1 has a narrow channel with steep slopes. Construction would be more difficult at this location, and more grading would be required than at DC2. DC1 has the highest quality benthic community among the three alternative sites.

Site DC2

Site DC2, immediately upstream of where Dillon Creek crosses 1100 North Road, is a wide, flat area where the Dillon Creek channel is braided. The area consists of a forested wetland and is a natural depositional area. Enhancing detention at site DC2 would require less grading than at sites DC1 and DC3, and the wetland vegetation would stabilize the soils and provide erosion control.

Site DC3

The channel of Dillon Creek at site DC3, the furthest upstream from Enchanted Hills, is narrow with steep banks. Construction would prove to be more difficult in this location as working area is limited, and considerable grading would be needed to create a wetland or sediment trap.

Dillon Creek is a legal drain, and therefore the construction of a sediment trap or wetland at any of the sites would require a permit from the County Surveyor, in addition to the Corp of Engineers. For all sites, property would also need to be acquired. Other possible negative effects include loss or modification of riparian habitat and disruption or destruction of natural hydrology and detention capabilities.

Recommendations

Table 8 outlines the benefits and disadvantages of each alternative for a sediment trap or constructed wetland on Dillon Creek.

Table 8

SUMMARY OF BENEFITS AND DISADVANTAGES OF SEDIMENT TRAP/CONSTRUCTED WETLAND ON DILLON CREEK

Options	Benefits	Disadvantages
Sediment Trap/Wetland at DC1	-Sediment removal for all water upstream of channels	-Narrow area with steep banks; construction and grading difficult -Permits and land -Maintenance and sediment removal -Highest quality benthic community
Constructed Wetland at DC2	-Sediment removal for water upstream of DC2 (not entire stream) -Enhanced use of a natural depositional area -Wide and relatively flat area, easier access for construction and grading	-Construction and grading difficult -Permits and land -Maintenance and sediment removal -Forested wetland
Sediment Trap/Wetland at DC3	-Sediment removal for water upstream of DC3 (not entire stream)	-Narrow area with steep banks; construction and grading difficult -Permits and land -Maintenance and sediment removal

We recommend investigating a constructed wetland at DC2. This site is wide and flat, compared to sites DC1 and DC3, and is likely a source area for sediment. Placing a constructed wetland at DC2 would allow settling of sediment and stabilization of the area during storm flow, and straightforward access for maintenance.

Improvements 5 and 6: Erosion Control on Development Sites and Sediment Traps and/or Stormwater Retention in the Leeland Addition (Martin Ditch) and South Shore Subwatersheds.

Leeland Addition Subwatershed

Martin Ditch collects stormwater runoff from surrounding agricultural areas, and flows into Lake Wawasee. The fields near Martin Ditch are classed as highly erodible lands and were included in the United States Department of Agriculture's Conservation Reserve Program (CRP) at one time. The contract has since expired, and the fields have been returned to cultivation. Reestablishing these fields in the CRP program would reduce the amount of sediment entering channels at the Leeland Addition. Erosion of the streambed between County Road 800 E and the Leeland Addition Road is also likely a source of sediment to the channels (NRCS, 1999). Stream bank stabilization measures are another option for Martin Ditch. Channel hardening, placing riprap along channel bottom and banks, is an option to reduce erosion of the streambed. Regrading, opening the canopy, and planting the banks with native herbaceous vegetation would stabilize the banks and reduce stream bank erosion. Both of these options would require disturbance of the natural, forested setting of Martin Ditch. Constructing a series of check dams, or riprap structures, at several locations in the streambed of Martin Ditch would dissipate energy and reduce the potential for streambed erosion to occur. This option would require a minimal disturbance of the existing setting.

The south side of the Leeland Addition road is a potential structural BMP site. However, construction there would require disturbance of a high quality hardwood forest. Alternatively, an in-lake sediment trap in the channel is also an option for sediment removal. This alternative may have landowner opposition, navigational, and land acquisition obstacles. Previous sources of sediment, such as the construction of the new Wawasee Middle School and the sanitary sewer borrow area, have since been vegetated.

Recommendations

Table 9 outlines the benefits and disadvantages of each alternative for erosion control and sediment traps at Leeland Addition (Martin Ditch).

Table 9

SUMMARY OF BENEFITS AND DISADVANTAGES OF EROSION CONTROL, SEDIMENT TRAPS AND STORMWATER RETENTION AT LEELAND ADDITION

Options	Benefits	Disadvantages
Re-establish CRP in farm fields surrounding Leeland Addition	-Reduce sediment entering Martin Ditch	-May encounter property owner resistance
Channel hardening	-Stabilize banks and streambed -Reduce sediment to Martin Ditch	-Severe disruption to wooded area -Land and permits
Series of riprap check dams	-Dissipate stream energy -Reduce erosion potential of streambed -Reduce sediment to Martin Ditch	-Minor disruption to wooded area -Land and permits
Regrading, opening the canopy, and planting banks of Martin Ditch	-Stabilize banks -Reduce sediment to Martin Ditch	-Severe disruption to wooded area -Land and permits
Wetland on Martin Ditch south of Leeland Addition Road	-Settling of sediment -Bank stabilization via wetland vegetation	-Small area, construction disruptive and difficult -Land and permits
Sediment trap on Martin Ditch south of Leeland Addition Road	-Settling of sediment	-Small area, construction disruptive and difficult -Land and permits
Sediment trap on Martin Ditch north of Leeland Addition Road in channel	-Settling of sediment -Easy access for sediment trap construction, maintenance, and sediment removal	-Possible land owner resistance -Navigational concerns -Land and permits

At this time, we recommend pursuing source control from surrounding farm operations. In addition, a series of riprap check dams on Martin Ditch and a sediment trap in the channel north of Leeland Addition Road will be investigated. These sites were selected as to provide the minimum amount of disturbance to the wooded area south of Leeland Addition road.

South Shore Subwatershed

The South Shore Area consists of a ditch draining runoff from the South Shore Golf Course and Route 13, and flowing into Lake Wawasee. It is likely that fertilizers and other chemicals used to treat the golf course are entering the South Shore Ditch via stormwater runoff. Approaching the management of the South Shore Country Club to talk about current chemical applications to the property, and potential for reducing these applications, is an option for source control. There is a small existing wetland area to the west of Route 13 owned by the South Shore Country Club, and it may be possible to improve the existing wetland to uptake more nutrients and slow the water flowing through it. This would require permits from the Army Corps of Engineers and the County Surveyor, and the land would need to be acquired. Severe bank erosion has been observed in the streambed to the east of Route 13, and it is likely a minor source of sediment to the lake. Opening the canopy and planting the banks with native herbaceous vegetation would serve to stabilize the banks and reduce stream bank erosion. Due to the small area, regrading may be difficult.

Creating a wetland east of Route 13 would likely slow down the water enough to remove sediment, and add some bank stability via vegetation. A sediment trap at that location would also serve the same purpose, however would not provide the added stability of vegetation. Due to the small area, one more option would be to provide bioretention at this location, which would be comprised of plantings covered with hardwood mulch. Water flowing through the ditch would be slowed and would filter through the hardwood mulch/plantings mixture removing sediment and nutrients. The land would need to be acquired, and permits from the Army Corp of Engineers and the County Surveyor would also be required. In the past, construction projects to the west of Route 13 were causing sediment to enter the ditch and subsequently enter Lake Wawasee. These construction projects are now complete, and this source is no longer considered a leading cause of sediment in the South Shore Ditch.

Recommendations

Table 10 outlines the benefits and disadvantages of each alternative for erosion control and sediment traps at South Shore ditch.

Table 10

SUMMARY OF BENEFITS AND DISADVANTAGES OF EROSION CONTROL, SEDIMENT TRAPS AND STORMWATER RETENTION AT SOUTH SHORE

Options	Benefits	Disadvantages
Approach South Shore Country Club regarding reducing chemical applications.	-Reduce nutrients entering South Shore Ditch	-May encounter property owner resistance
Improve existing wetland on South Shore Country Club, west of Rte 13	-Settling out of sediment	-Land and permits
Regrading and planting of banks on South Shore Ditch	-Bank stabilization -Reduction of sediment to South Shore Ditch	-Small area, construction disruptive and difficult -Land and permits
Wetland east of Rte 13 on South Shore Ditch	-Settling out of sediment -Bank stabilization via wetland vegetation	-Small area, construction disruptive and difficult -Land and permits
Bioretention east of Rte 13 on South Shore Ditch	-Settling out of sediment -Nutrient Removal -Will work in small area	-Land and permits -Maintenance and sediment removal

At this time, we recommend a feasibility evaluation of source control at the golf course. In addition, the sediment trap and bioretention options will be investigated. The site to the east of Rte 13 was selected as to provide the least amount of disturbance to the existing wetland west of Rte 13.

Improvement 7: <u>A Reconstructed Wetland in the Bayshore Swamp</u>. The Bayshore Area consists of a residential area developed around dredged boat channels to the lake. The Bayshore channel is fed by a ditch that collects agricultural runoff also from fields to the south of Hatchery Road. Large sediment plumes have been likewise observed where the Bayshore channel enters Lake Wawasee. There is an existing wetland system to the south of Hatchery Road that could be reconfigured to maximize sediment removal. The wetland spans from west of CR 850W to east of CR 850W, with a culvert under the road. One option is to create a sheetpile impoundment at the outlet of the wetland to the west of CR 850W before the water enters the culvert under the road. This would contain the water to the west of the road, and release it slowly through the culvert the wetland to the east of CR 850W. Creating the impoundment would slow the water and allow sediment to settle out. Another option would be to incorporate the recreational ponds on the west side of the road to slow the water before entering the wetlands. The stream to the south of the ponds could be diverted first into the eastern-most pond and then back into the wetland to the north (NRCS, 1998). This would allow the sediment additional time to settle out before reaching the wetlands, and subsequently, Lake Wawasee. Both of these options involve reconstruction of existing wetlands, and would require permits from the Army Corp of Engineers and the County Surveyor. Both options would also require the land to be acquired or leased. Should alterations of the existing ponds be selected, the owner would have to be amenable to the potential impairment of the ponds for recreational uses such as swimming or fishing. Alternatively, an in-lake sediment trap in the channel is also an option for sediment removal. This alternative may have landowner opposition, navigational, and land acquisition obstacles.

Recommendations

Table 11 outlines the benefits and disadvantages of each alternative for a reconstructed wetland in the Bayshore Swamp.

Table 11

SUMMARY OF BENEFITS AND DISADVANTAGES OF RECONSTRUCTED WETLAND AT BAYSHORE SWAMP

Options	Benefits	Disadvantages
Impoundment on wetland west of CR 850E	-Settling out of sediment	-Land and permits -Possible homeowner resistance
Redirecting water through pond before entering wetland west of CR 850E	-Enhanced settling out of sediment	-Possible impairment of pond for swimming and fishing -Land and permits -Possible homeowner resistance
Sediment trap in Bayshore channel	-Settling of sediment -Easy access for sediment trap construction, maintenance, and sediment removal	-Possible land owner resistance -Navigational concerns -Land and permits

At this time, we recommend investigating the impoundment on the wetland west of CR 850E. This option will back up the water and allow settling of sediment, without the loss of the recreational benefits of the ponds. We also recommend investigating the in-channel sediment trap at Bayshore, which would provide sediment removal while allowing easy access for maintenance and sediment removal.

References:

Natural Resources Conservation Service (NRCS), 1998. Letter from Samuel St. Clair to Betty Knapp regarding Bayshore Addition.

Natural Resources Conservation Service (NRCS), 1999. Letter from Samuel St. Clair to Bob Myers regarding Leeland Addition/Martin Ditch.

HARZA ENGINEERING COMPANY
WATER & ENVIRONMENT

ENCHANTED HILLS EROSION SURVEY
LAKE WAWASEE ENGINEERING FEASIBILITY STUDY
Site Selection Technical Memorandum

Figure 1

Appendix B: Sample Permit Applications

01/29/2001 11:24:31 AM EST

STATE OF INDIANA
DEPARTMENT OF NATURAL RESOURCES

JOINT PERMIT APPLICATION FOR CONSTRUCTION WITHIN A FLOODWAY OF A STREAM OR RIVER; NAVIGABLE WATERWAY; PUBLIC FRESH WATER LAKE; AND DITCH RECONSTRUCTION

*** INSTRUCTIONS ***

This joint application can be used to apply for: (1) alteration of the bed or shoreline of a public freshwater lake; (2) construction or reconstruction of any ditch or drain having a bottom depth lower than the normal water level of a freshwater lake of 10 acres or more and within 1/2 mile of the lake; (3) construction within the floodway of any river or stream; (4) placing, filling, or erecting a permanent structure in; water withdrawal from; or material extraction from; a navigable waterway; (5) extraction of mineral resources from or under the bed of a navigable waterway; and (6) construction of an access channel. **You must submit readable copy of the completed application form together with items stated in the "Application Checklist" (attached).**

Use the following checklist to determine which permit(s) to apply for. If you have trouble deciding which permit(s) you need, please contact the Permit Administration Section at (317) 233-5635.

Your project may require one or more of the following permits. **IF YOU CHECK ANY BOX UNDER A PERMIT TITLE, THEN YOU MUST APPLY FOR THAT PERMIT.**

- ☐ **IC 14-26-2:** **Lake Preservation Act** states that no person may change the level of the water or shoreline of a public freshwater lake by excavating, filling in, or otherwise causing a change in the area or depth or affecting the natural resources scenic beauty or contour of the lake below the waterline or shoreline, without first securing the written approval of the Department of Natural Resources. A written permit from the Department is also required for construction of marinas; new seawall; seawall refacing; underwater beaches; boatwells; boat well fills; fish attractors; and any permanent structures within the waterline or shoreline of a public freshwater lake. The Act further states that **each permit application must be accompanied by a non-refundable $25 fee.**
- ☐ **IC 14-26-5:** **Lowering of the Ten Acre Lake Act also know as the "Ditch" Act** states that no person may order or recommend the location, establishment, construction, reconstruction, repair, or recleaning any ditch or drain having a bottom depth lower than the normal water level of a freshwater lake of 10 acres or more and within 1/2 mile of the lake without first securing the written approval of the Department of Natural Resources. The Act further states that **each permit application must be accompanied by a non-refundable $25 fee.**
- ☐ **IC 14-28-1:** **Flood Control Act** requires that any person proposing to construct a structure, place fill, or excavate material within the floodway of any river or stream must obtain the written approval of the Department of Natural Resources prior to initiating the activity. The Act further states that **each permit application must be accompanied by a non-refundable $50 fee.**
- ☐ **IC 14-29-1:** **Navigable Waterways Act** requires that prior written approval be obtained from the Department of Natural Resources for placing, filling, or erecting a permanent structure in; water withdrawal from; or mineral extraction from; a navigable waterway or Lake Michigan. **No Fee**

☐ **IC 14-29-3:** **Sand and Gravel Permits Act** requires that prior written approval be obtained from the Department of Natural Resources for removal of sand, gravel, stone, or other mineral or substance from or under the bed of a navigable waterway. The Act further states that **each permit application must be accompanied by a non-refundable $50 fee.**

☐ **IC 14-29-4:** **Construction of Channels Act** requires that prior written approval of the Department of Natural Resources be obtained for construction of an artificial; or the improved channel of a natural watercourse; connecting to any river or stream for the purpose of providing access by boat or otherwise to public or private industrial, commercial, housing, recreational, or other facilities. **Each permit application must be accompanied by a non-refundable $100 fee.**

State Form 42946 (R2/3-98)
Approved by the State Board of Accounts

PERMIT APPLICATION

Mail To: Division of Water
Department of Natural Resources
402 West Washington Street, Room W264
Indianapolis, Indiana 46204-2748
Telephone Number: (317) 233-5635
Fax Number: (317) 233-4579

AGENCY USE ONLY

Application # ________	Section Coordinates	UTM North ______	UTM East ______
30 Day Notice ________	Fee Submitted $ ______	Check # ______	Receipt # ______

Based on the "INSTRUCTIONS", I am submitting this application to perform work under:

☐ *IC 14-26-2 Lake Preservation Act*
☐ *IC 14-26-5 Lowering of the Ten Acre Lake Act*
☐ *IC 14-28-1 Flood Control Act*
☐ *IC 14-29-1 Navigable Waterways Act*
☐ *IC 14-29-3 Sand and Gravel Permits Act*
☐ *IC 14-29-4 Construction of Channels Act*

PLEASE TYPE OR PRINT

1. APPLICANT INFORMATION

Name of Applicant ______________________________

Name of Contact Person ______________________________

Mailing Address ______________________________ (Street, P.O. Box or Rural Route)

______________ City ______________ State ______________ Zip Code

Daytime Telephone Number (____)______________

Fax Number (____)______________

2.AGENT INFORMATION

Name of Authorized Agent ______________________________

Name of Contact Person ______________________________

Mailing Address ______________________________ (Street, P.O. Box or Rural Route)

______________ City ______________ State ______________ Zip Code

Daytime Telephone Number (____)______________

Fax Number (____)______________

3.PROPERTY OWNER INFORMATION

Name of Property Owner ____

Name of Contact Person ____

Mailing Address ____
(Street, P.O. Box or Rural Route)

City	State	Zip Code

Daytime Telephone Number (____)________________

Fax Number (____)________________

Relationship of applicant to property:

☐ Owner ☐ Purchaser ☐ Lessee ☐ Other ________________

4. AFFIRMATION OF PERSONAL SERVICE, 1ST CLASS MAIL SERVICE, OR CERTIFIED MAIL SERVICE

FORM N-2

I have provided public notice to the listed property owners in conformance with the provisions of IC 14-11-4 and 312 IAC 2-3-3 through the method indicated below.

(Check the appropriate Box - ***Please make copies of this blank page if additional pages are required*****)**

Property Owner (if not applicant or adjacent landowner) Address City State Zip Code	☐ Personal Service was provided on :_________ (date) ☐ 1st Class Mail Service was provided on: ______(date) I affirm that 21 days have passed without the mailing returned as undelivered or undeliverable. PS Form 3817 is attached as proof of mailing. ☐ Certified Mail service was provided on:______(date) PS Form 3811 (green card) is attached as proof of mailing.
Adjacent Landowner: Address City State Zip Code	☐ Personal Service was provided on :_________ (date) ☐ 1st Class Mail Service was provided on: ______(date) I affirm that 21 days have passed without the mailing returned as undelivered or undeliverable. PS Form 3817 is attached as proof of mailing. ☐ Certified Mail service was provided on:______(date) PS Form 3811 (green card) is attached as proof of mailing.
	☐ Personal Service was provided on :_________ (date)

	:_________ (date)
Adjacent Landowner:	☐ 1st Class Mail Service was provided on: ______(date) I affirm that 21 days have passed without the mailing returned as undelivered or undeliverable. PS Form 3817 is attached as proof of mailing.
Address	
City State Zip Code	☐ Certified Mail service was provided on:______(date) PS Form 3811 (green card) is attached as proof of mailing.

5. PROJECT DESCRIPTION

5.1 Description Narrative: (See Application Assistance Manual)

6.PROJECT LOCATION
6-1 Location Narrative: (See Application Information Packet)
Stream/Lake Name
6-2 Driving Directions: (See Application Information Packet)
6-3 Special Information: (See Application Information Packet)
6-4 Project Location Map: (See Application Information Packet)
6-5 Project Site Map: (See Application Information Packet)

7. DISTURBED AREA DRAWING
7.1 Drawing Requirements: (See Application Information Packet)

8. PROJECT PHOTOGRAPHS
8-1 Images: (See Application Information Packet)
8-2 Photo Orientation Map: (See Application Information Packet)
8-3 Photo Documentation: (See Application Information Packet)

9. RELATED PROJECT INFORMATION	
Department of Natural Resources	
Administrative Cause #	Related Application(s) #
Early Coordination #	Utility Exemption #
Recommendation #	Violation #
Department of Environmental Management	
Section 401 #	
Corps of Engineers	
Public Notice #	Section 10 Application #
Section 404 Application #	

10. STATEMENT OF AFFIRMATION

I hereby swear or affirm, under the penalties for perjury, that the information submitted herewith is to the best of my knowledge and belief, true, accurate and complete, and that the property owner (s), and adjoining landowners have been notified of the activity in conformance with the provisions of 312 IAC 2-3-3. I further certify that I possess the authority to undertake the proposed or completed activities. I hereby grant to the Department of Natural Resources, the right to enter the above-described location to inspect the proposed or completed work.

_______________________________________ _______________________

Signature of Applicant or Authorized Agent *(REQUIRED)* Date

11. REGULATORY FEES
11-1 Regulatory Fees Submitted: (See Application Information Packet)
11-3 Payment Method: (See Application Information Packet)

REQUIREMENT FOR ADDITIONAL INFORMATION AND PERMITS
Application made to and approval granted by the Department of Natural Resources does not in any way relieve the applicant of the necessity of securing easements or other property rights, permits and approvals from affected property owners and other local, state, and federal agencies.

Form N2

PUBLIC NOTICE

Adjacent Property Owner's Name
Address
City, State, Zip Code

Date: ______________

Indiana Code 14-11-4 was enacted to ensure that adjacent property owners are notified of permit applications and provided with an opportunity to present their views to the Department of Natural Resources prior to action.

> Under the legislation, the applicant or agent is responsible for providing notice to the owner of the real property owned by a person, other than the applicant, which is both of the following: 1.) located within one-fourth (1/4) mile of the site where the licensed activity would take place, and 2.) has a border or point in common with the exterior boundary of the property where the licensed activity would take place. Included is property which would share a common border if not for the separation caused by a roadway, stream, channel, right-of-way, easement, or railroad.

Due to your proximity to the project site, you are considered to be an adjacent property owner; therefore, notice is being provided in conformance with the provisions of IC 14-11-4 and 312 IAC 2-3.

Applicant's Name, Address, and Telephone
____
____

Agent's Name, Address, and Telepho
____
____

Stream or Lake Name:
____

Project Description and Location:
____
____

Check relevant Statute or Rule:

- ☐ Flood Control Act, IC 14-28-1
- ☐ Lake Preservation Act, IC 14-26-2
- ☐ "Ditch Act", IC 14-29-4
- ☐ Channels Act, IC 14-29-4
- ☐ Removal of Sands or Gravel, IC 14-29-3

Questions relating to the project should be directed to:

Applicant (or Agent) Name
Mailing Address
City, State, Zip Code
Telephone Number

You may request an informal public hearing, pre-AOPA (Administrative Orders and Procedures Act) hearing, on this application by filing a petition with the Division of Water. The petition must conform to administrative rule 312 IAC 2-3-4 as follows:

a. This section establishes the requirements for a petition to request a public hearing under IC 14-11-4-8(a)(2).
b. the petition shall include the signatures of at least twenty-five (25) individuals who are at least eighteen (18) years of age and who reside in the county where the licensed activity would take place or who own real property within one (1) mile of the site of the proposed or existing licensed activity.
c. the complete mailing addresses of the petitioners shall by typed or printed legibly on the petition.
d. each individual who sighs the petition shall affirm that the individual qualifies under subsection (b).
e. The petition shall identify the application for which a public hearing is sought, either by application number or by the name of the applicant and the location of the project.

A pre-AOPA public hearing on the application will be limited to the Department's authority under the permitting statues. Only the issues relevant to the Department's jurisdiction directly related to this application for construction will be addressed. Under permitting statues, the Department has no authority in zoning, local drainage, burning, traffic safety, etc.; therefore, topics beyond the Department's jurisdiction will not be discussed during the public hearing.

You may also request that the Department notify you in writing when an initial determination is made to issue or deny the permit. Following the receipt of the post action notice, you may request administrative review of the determination by the Natural Resources Commission under IC 14-21.5 and 312 IAC 2-3.

A request for a pre-AOPA public hearing or notice of initial determination should be addresses to:

Permit Administration Section
Division of Water
Department of Natural Resources
402 West Washington Street, Room W264
Indianapolis, Indiana 46204-2748
Telephone: (317) 233-5635

The Department's jurisdiction under the Flood Control Act is confined to the floodway of the stream and its review limited to the following criteria.

To be approvable a project must demonstrate that it will:

a. not adversely affect the efficiency or unduly restrict the capacity of the floodway; defined as, the project will not result in an increase in flood stages of more than 0.14 feet above the base 100-year regulatory flood elevation.
b. not constitute an unreasonable hazard to the safety of life or property; defined as, the project will not result in either of the following during the regulatory flood: (1) the loss of human life, (2) damage to public or private property to which the applicant has neither ownership nor a flood easement;
c. not result in unreasonably detrimental effects upon fish, wildlife or botanical resources.

Additionally, the Department must consider the cumulative effects of the above items.

the Department's jurisdiction under the Lakes Preservation Act is confined to the area at or lakeward of the shoreline of the lake and any impact which the project may have on:

a. the natural resources and/or scenic beauty of the lake;
b. the water level or contour of the lake below the waterline;
c. fish, wildlife or botanical resources.

Additionally, the department must consider the cumulative effects of the above items.

**Office of Water Management
Section 401 Water Quality
Certification Program**

Application Form and Instructions for Section 401 Water Quality Certification

Note to applicants:

Applicants should also contact the Indiana Department of Natural Resources (DNR) regarding potential permit requirements associated with construction in a floodway or a public freshwater lake. According to 1998 figures, approximately 9% of the projects that required a Section 401 Water Quality Certification also required a permit from the DNR. You can reach the DNR Division of Water at 317-232-4160 or toll free at 1-877-WATER55.

Revised February 14, 2000

Dear Section 401 Water Quality Certification Applicants:

Thank you for doing your part to ensure that we are all good stewards of Indiana's lakes, rivers, streams, and wetlands. We at the Indiana Department of Environmental Management (IDEM) are committed to protecting the integrity of our State's precious aquatic resources.

In accordance with Section 401 of the Clean Water Act (CWA), any applicant for a federal license or permit to conduct any activity that may result in a discharge into waters of the United States must first obtain a Water Quality Certification (WQC) (or waiver) from the state. In general, anyone who is required to obtain a permit from the U.S. Army Corps of Engineers (Corps) to engage in dredging, excavation or filling activities must obtain a WQC.

IDEM's goal is to preserve, protect, and enhance the quality of Indiana's aquatic resources. We want to work with you to find sound ecological solutions that meet your project needs. We have developed an application packet that sets forth the information we need from you to make a decision regarding your project. We believe it is relatively simple to complete.

Please contact us with any questions or concerns you may have. You can reach us at 317-233-8488, or you may reach us through the IDEM Environmental Helpline at 1-800-451-6027. Thank you again for doing your part to ensure that Indiana's aquatic resources are protected for future generations of Hoosiers.

Sincerely,

Matthew C. Rueff
Assistant Commissioner
Office of Water Management

FREQUENTLY ASKED QUESTIONS REGARDING WATER QUALITY CERTIFICATION (WQC)

1. Who needs a WQC?

Any applicant for a federal license or permit to conduct any activity that may result in a discharge into waters of the United States must first obtain a WQC (or waiver) from the state. In general, anyone who is required to obtain a permit from the U.S. Army Corps of Engineers to engage in dredging, excavation or filling activities must obtain a WQC.

2. What is a water of the United States?

Very few waterbodies are not waters of the United States. Waters of the United States include: waters that are or have been used to transport commerce and their tributaries; all interstate waters; and all intrastate waters the use, degradation or destruction of which could affect commerce. This generally includes lakes, rivers, streams, creeks, drainage ditches and wetlands. The Corps can tell you whether the particular waterbody you plan on impacting is a water of the United States.

3. What type of project may require a WQC and Corps permit?

The Corps has the authority to decide which projects require a permit and whether they will qualify for a Nationwide Permit, General Permit, or Individual Permit. The addresses and telephone numbers for the two Corps Districts that have jurisdiction in Indiana are included at the back of this packet. The following are examples of projects that would likely require a Corps permit and WQC: dredging a lake, river, stream, or wetland; filling a lake, river, stream, or wetland; bank stabilization; pond construction in wetlands; and roadway/bridge construction projects involving water crossings.

4. If my project qualifies for a Nationwide Permit from the Corps, do I still need a WQC?

IDEM has given a blanket WQC for some, but not all, of the Nationwide Permits (NWPs) established by the Corps. If IDEM has not given a blanket WQC for the particular NWP the Corps has authorized you to work under, then an individual WQC from IDEM will be necessary. The Corps will inform you if your project needs an individual WQC. You may also request a list of the NWPs for which IDEM has granted certification and NWPs that IDEM has certified with special conditions.

5. How long will it take me to obtain a WQC?

If IDEM receives all the necessary information, then IDEM can usually make a decision on your application within sixty days of receiving it. However, the Clean Water Act authorizes IDEM to take up to a year to make a decision on your application.

6. Is there an application fee for obtaining a WQC?

Currently, there are no fees required for applying for a WQC.

Instructions for Completing the Application for Water Quality Certification

* The numbers below correspond to the numbers on the application form

* If you have questions, please call IDEM's Water Quality Certification Program at 1-800-451-6027 or 317-233-8488

* Print clearly or type

* Attach additional 8 " x 11" sheets if necessary

1. Provide the applicant's name, address, and telephone number. Applicants MUST provide a contact name.

2. Provide the agent's address and telephone information (an agent is anyone representing the applicant on the project, such as an attorney or consultant). Applicants are not required to have an agent.

3. Provide specific project information relating to the location of the proposed project. Include the Universal Transverse Mercator (UTM) coordinates including the datum (eg. 1927 North American). UTM coordinates can be obtained from the United States Geological Survey (USGS) 7.5-Minute Series Topographic Quadrangle maps.

4. Give a narrative description of the proposed project and its purpose (i.e., why the project is being proposed).

5. Answer the five questions. If not applicable for the proposed project indicate so in the blank.

6. Drawing/Plan requirements. All applicants must submit drawings/plans consistent with the specifications under item six.

7. **For all projects involving impacts to wetlands** a Corps of Engineers approved wetland delineation is **required** to enable the department in determining the impacts to water quality associated with the project. Photographs aid the department in deciding if a site investigation is necessary, and how best to locate the impact areas when site investigations are necessary.

8. Applicants are not required to submit the information specified in this section unless directed to do so by the department. However, applicants may submit the information if they anticipate that such information will be required.

Instructions are continued immediately after the pull out application

Application for Water Quality Certification

Address all applications or questions to:

Indiana Department of Environmental Management
Section 401 Water Quality Certification Program
100 North Senate Avenue P.O. Box 6015 Indianapolis, Indiana 46206-6015
1-800-451-6027 or 317-233-8488

PLEASE PULL OUT APPLICATION FROM PACKET

Failure to provide the information requested in this application may result in a delay of processing or denial of your application.

For office use only
Project Manager:
Date Received:
IDEM I.D. Number:
County:

1. APPLICANT INFORMATION	2. AGENT INFORMATION
Name of Applicant	Name of Agent
Mailing address (Street/ PO Box/ Rural Route, City, State, Zip)	Mailing address (Street/ PO Box/ Rural Route, City, State, Zip)
Daytime Telephone Number	Daytime Telephone Number
Fax Number	Fax Number
E-mail address (optional)	E-mail address (optional)
Contact person: (required)	Contact person:

3. PROJECT LOCATION			
County		Nearest city or town	
U.S.G.S. Quadrangle map name (Topographic map)		Project street address (if applicable)	
Quarter	Section	Township	Range
Type of aquatic resource(s) to be impacted (lake, river, stream, ditch, wetland, etc. include name if applicable)		Project name or title (if applicable)	
		UTM North	UTM East
Other location descriptions or driving directions			

4. PROJECT PURPOSE and DESCRIPTION	
Use additional sheet(s) if required	
Has any construction been started? YES NO	Anticipated start date
If yes, how much work is completed?	
Project purpose and description	

5. Project Information: Applicants must answer all the following questions.

What are the linear feet of impacts to the waterbody below the ordinary high water mark (OHWM) and/or bank clearing?

What is the acreage or square footage of wetlands or other water resources that are proposed to receive a discharge of material (ie. fill), mechanically cleared, or to be excavated?

What is the area of wetlands or other water resources on the site, in acreage or square feet?

Describe the type, composition and quantity (in cubic yards) of fill material to be placed in the wetland or below the OHWM of the water to receive the material (wetland or other water to be filled).

Describe the type, composition and quantity (in cubic yards) of material proposed to be removed from the wetland or below the OHWM of the water resource.

6. Drawing/Plan Requirements (applicants must provide the following)

a. Top/aerial/overhead view of the project site

b. Cross sectional view

c. North arrow, scale, property boundaries

d. Include wetland delineation boundary (if applicable). Label the impact wetlands as I-1, I-2, etc. and mitigation areas as M-1, etc.

e. Location of all surface waters, including wetlands, proposed works, erosion control measures, existing structures, disposal area for excavated material, fill locations, including quantities, and wetland mitigation (if applicable)

f. Approximate water depths and bottom configurations (if applicable)

g. Provide plans on 8 by 11 inch paper, unless directed otherwise

7. Documentation Requirements (applicants must provide the following)

a. A Corps of Engineers approved wetland delineation for projects with wetland impacts

b. Photographs of the project site. Indicate where they were taken on the overhead view of the project plans

8. Additional information that MAY be required (IDEM will notify you if needed)

a. Erosion control and/or storm water management plans

b. Sediment analysis

c. Wetland mitigation plan including: type, size, location, methods of construction, planting and monitoring plans

d. Species surveys for fish, mussels, plants and threatened or endangered species

e. Any other information IDEM deems necessary to determine the impact to water quality

9. Permitting Requirements

a. Have you applied for an Army Corps of Engineers Section 404 permit? _____ Yes _____ No If yes, please supply the Corps of Engineers ID Number, the Corps of Engineers District, the project manager, and a copy of any correspondence with the Corps. **If no, contact** the Army Corps of Engineers regarding the possible need for a permit application. (See instructions 11.)

b. Have you applied for, received, or been denied any other federal, state, or local permits, variances, licenses, or certifications for this project? Please give the permit name, agency from which it was obtained, permit number, and date of issuance or denial.

10. Adjoining Property Owners and Addresses

List the names and addresses of landowners adjacent to the property on which your project is located and the names and addresses of other persons (or entities) potentially affected by your project. Use additional sheet(s) if required.

Name Address City State Zip	Name Address City State Zip
Name Address City State Zip	Name Address City State Zip
Name Address City State Zip	Name Address City State Zip
Name Address City State Zip	Name Address City State Zip
Name Address City State Zip	Name Address City State Zip

11. Signature - Statement of Affirmation

I hereby request a Water Quality Certification to authorize the activities described in this application. I certify that I am familiar with the information contained in this application and to the best of my knowledge and belief, such information is true and accurate. I certify that I have the authority to undertake and will undertake the activities as described in this application. I am aware that there are penalties for submitting false information. I understand that any changes in project design subsequent to IDEM's granting of WQC are not covered by the WQC, and I may be subject to civil and criminal penalties for proceeding without proper authorization. I agree to allow representatives of the IDEM to enter and inspect the project site. I understand that the granting of other permits by local, state, or federal agencies does not release me from the requirement of obtaining the WQC requested herein before commencing the project.

Applicant's Signature: ________________________________ Date: ________________

Instructions continued

9. Provide information regarding your application to the U.S. Army Corps of Engineers. If you have not contacted the Corps of Engineers, please call the Louisville Corps District at 502/582-5607 or the Detroit Corps District at 313/226-6828. Please consult the map on the next page to determine which district your project is located in.

10. Provide information regarding any other federal, state, or local permits, variances, licenses, or certifications required for your project. Please indicate whether they were approved, denied, or are pending.

11. The applicant must sign and date the application.

Where to get additional information

For more information about WQC, contact IDEM at the address below. Please contact the DNR or respective Corps District at the proper address below for questions regarding their programs.

IDEM - Office of Water Management
Section 401 Water Quality Certification Program
P.O. Box 6015
IGCN Room 1255
Indianapolis, IN 46206-6015
317-233-8488 or toll free at 1-800-451-6027
http://www.state.in.us/idem/owm/planbr/wqs/401home.htm

Indiana Department of Natural Resources (DNR)
Division of Water
402 W. Washington Street, Room W200
Indianapolis, IN 46204
317-232-4161 or toll free at 1-877-Water55 (1-877-928-3755)
http://www.state.in.us/dnr/water/

United States Army Corps of Engineers
Detroit District
P.O. Box 1027
Detroit, MI 48231-1027
313-226-2218
http://huron.lre.usace.army.mil/regu/dtwhome.html

United States Army Corps of Engineers
Louisville District
P.O. Box 59
Louisville, KY 40201-0059
502-582-6461
http://www.lrl.usace.army.mil/orf/default.htm

Indiana Department of Environmental Management
Section 401 Water Quality Certification Program
100 North Senate Avenue
P.O. Box 6015
Indianapolis, Indiana 46206-6015

PRINT PERMIT APPLICATIONS PAGE

Please find below your choice of Permit Application Forms. Again, many inland waters in the State of Michigan have been delegated to the Michigan Department of Enviornmental Quality (MDEQ) for regulatory activities. If you anticipate any work in a navigable water in the State of Michigan, you will need to complete a joint permit application prior to starting any work. For any proposed work in the northern third of Indiana, you will need to complete the standard permit application form from below.

NOTE: If these are unusable for you, please contact a Regulatory Office nearest you.

A copy of Adobe Acrobat Reader Software is required to view and/or print some of these files.

Get Acrobat Adobe Reader

Michigan JOINT Permit

Indiana STANDARD Permit PDF

Return to the Detroit District Regulatory Home Page

Contributions & Suggestions ARE Welcome ! !
Please contact Doug Rail, Via E-Mail:
R.Doug.Rail@lre02.usace.army.mil

APPLICATION FOR DEPARTMENT OF THE ARMY PERMIT **OMB APPROVAL NO. 0710-003**
(33 CFR 325)

Public reporting burden for this collection of information is estimated to average 5 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Department of Defense, Washington Headquarters Service Directorate of Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302; and to the Office of Management and Budget, Paperwork Reduction Project (0710-0003), Washington, DC 20503. Please DO NOT RETURN your form to either of those addresses. Completed applications must be submitted to the District Engineer having jurisdiction over the location of the proposed activity.

PRIVACY ACT STATEMENT

Authority: 33 USC 401, Section 10: 1413, Section 404. Principal Purpose: These laws require authorizing activities in, or affecting, navigable waters of the United States, the discharge or fill material into waters of the United States, and the transportation of dredged material for the purpose of dumping it into ocean waters. Routine Uses: Information provided on this form will be used in evaluating the application for a permit. Disclosure: Disclosure of requested information is voluntary. If information is not provided, however, the permit application cannot be processed nor can a permit be issued. One set of original drawings or good reproducible copies which show the location and character of the proposed activity must be attached to this application (see sample drawings and instructions) and be submitted to the District Engineer having jurisdiction over the location of the proposed activity. An application that is not completed in full will be returned.

(ITEMS 1 THRU 4 TO BE FILLED BY THE CORPS)

1. APPLICATION NO. 2. FIELD OFFICE CODE 3. DATE RECEIVED 4. DATE APPLICATION COMPLETED

(ITEMS BELOW TO BE FILLED BY APPLICANT)

5. APPLICANT'S NAME

6. APPLICANT'S ADDRESS

7. APPLICANT'S PHONE NOs. W/AREA CODE
   a. Residence
   b. Business

8. AUTHORIZED AGENT'S NAME AND TITLE (an agent is not required)

9. AGENT'S ADDRESS

10. AGENT'S PHONE NOs. W/AREA CODE
   a. Residence
   b. Business

11. **STATEMENT OF AUTHORIZATION**

I hereby authorize, ______________________ to act in my behalf as my agent in the processing of this application and to furnish, upon request, supplemental information in support of this permit application.

APPLICANT'S SIGNATURE DATE

NAME, LOCATION, AND DESCRIPTION OR PROJECT OR ACTIVITY

12. PROJECT NAME OR TITLE (see instructions)

13. NAME OF WATERBODY, IF KNOWN (if applicable)

14. PROJECT STREET ADDRESS (if applicable)

15. LOCATION OF PROJECT

COUNTY STATE

16. OTHER LOCATION DESCRIPTIONS, IF KNOWN (see instructions) **Section, Township, Range, Lat/Lon, and/or Accessors's Parcel Number, for example.**

17. DIRECTIONS TO THE SITE

18. Nature of Activity (Description of project, include all features)

19. Project Purpose (Describe the reason or purpose of the project, see instructions)

USE BLOCKS 20-22 IF DREDGED AND/OR FILL MATERIAL IS TO BE DISCHARGED

20. Reason(s) for Discharge

21. Type(s) of Material Being Discharged and the Amount of Each Type in Cubic Yards

22. Surface Area in Acres of Wetlands or Other Waters Filled (see instructions)

23. Is Any Portion of the Work Already Complete? Yes ___ No ___ IF YES, DESCRIBE THE COMPLETED WORK

24. Addresses of Adjoining Property Owners, Lessees, Etc., Whose Property Adjoins the Waterbody (If more than can be entered here, please attach a supplemental list).

25. List of Other Certifications or Approvals/Denials Received from other Federal, State, or Local Agencies for Work Described in This Application.

AGENCY	TYPE APPROVAL*	IDENTIFICATION NUMBER	DATE APPLIED	DATE APPROVED	DATE DENIED

* Would include but is not restricted to zoning, building, and flood plain permits

26. Application is hereby made for a permit or permits to authorize the work described in this application. I certify that the information in this application is complete and accurate. I further certify that I possess the authority to undertake the work described herein or am acting as the duly authorized agent of the applicant.

SIGNATURE OF APPLICANT DATE SIGNATURE OF AGENT DATE

The application must be signed by the person who desires to undertake the proposed activity (applicant) or it may be signed by a duly authorized agent if the statement in block 11 has been filled out and signed.

18 U.S.C. Section 1001 provides that: Whoever, in any manner within the jurisdiction of any department or agency of the United States knowingly and willfully falsifies, conceals, or covers up any trick, scheme, or disguises a material fact or makes any false, fictitious or fraudulent statements or representations or makes or uses any false writing or document knowing same to contain any false, fictitious or fraudulent statements or entry, shall be fined not more than $10,000 or imprisoned not more than five years or both.

Appendix C: Enchanted Hills Property Owners

KEY	OWNER_NAME	OWNER_ADD1	OWNER_ADD2
007-050-701	MAGGART ROBERT K & DELORIS	11770 N ROBINHOOD RD A92	CROMWELL, IN 46732
007-050-702	REISINGER ELEANOR ANN ETAL TO ARMONTROUT	13216 DELAWARE	CROWN POINT, IN 46307
007-050-703	BOWERS LAWERENCE G JR & ZEFRA ILENE	5742 GOSHEN RD	FT WAYNE, IN 46808
007-050-724	S A M ENTERPRISE OF SOUTH BEND INC	PO BOX 586	ST JOSEPH, MI 49085
007-050-725	BUTTS MARJORIE	2757 LENSON CT	MISHAWAKA, IN 46544
007-050-726	KEENE MARGARET A	9435 E STREET OF DREAMS	CROMWELL, IN 46732
007-050-727	S A M ENTERPRISE OF SOUTH BEND INC	PO BOX 586	ST JOSEPH, MI 49085
007-050-792	S A M ENTERPRISE OF SOUTH BEND INC	PO BOX 586	ST JOSEPH, MI 49085
007-050-793	S A M ENTERPRISE OF SOUTH BEND INC	PO BOX 586	ST JOSEPH, MI 49085
007-050-728	S A M ENTERPRISE OF SOUTH BEND INC	PO BOX 586	ST JOSEPH, MI 49085
007-050-794	MCCULLOUGH THOMAS E & JUDITH L	3103 W 330 N	ALBION, IN 46701
007-050-729	S A M ENTERPRISE OF SOUTH BEND INC	PO BOX 586	ST JOSEPH, MI 49085
007-050-730	SMITH TERRY E	9727 N KOHER RD E	SYRACUSE, IN 46567
007-050-833	S A M ENTERPRISE OF SOUTH BEND INC	PO BOX 586	ST JOSEPH, MI 49085
007-050-834	S A M ENTERPRISE OF SOUTH BEND INC	PO BOX 586	ST JOSEPH, MI 49085
007-050-835	S A M ENTERPRISE OF SOUTH BEND INC	PO BOX 586	ST JOSEPH, MI 49085
007-050-731	S A M ENTERPRISE OF SOUTH BEND INC	PO BOX 586	ST JOSEPH, MI 49085
007-050-748	MILICKI STEVE V & MARY JTWROS	641 N LAFAYETTE	GRIFFITH, IN 46319
007-050-747	BARNA ALEX & OLEGA TO LOMNICKY ANTHONY &	12016 VAN BEVEREN DRIVE	ALSIP, IL 60658
007-050-732	S A M ENTERPRISE OF SOUTH BEND INC	PO BOX 586	ST JOSEPH, MI 49085
007-050-746	S A M ENTERPRISE OF SOUTH BEND INC	21340 KERN ROAD	SOUTH BEND, IN 46614-9756
007-050-745	ARMONTROUT WILLIAM L & ELEANORE A	13216 DELAWARE ST	CROWN POINT, IN 46307
007-050-744	ARMONTROUT WILLIAM L & ELEANORE A	13216 DELAWARE ST	CROWN POINT, IN 46307
007-050-733	S A M ENTERPRISE OF SOUTH BEND INC	PO BOX 586	ST JOSEPH, MI 49085
007-050-743	MEINERT SHEILA HUEBNER	28781 CR 42 R 1	WAKARUSA, IN 46573
007-050-742	DEWITT FRANCES	1751 WOODS DR 0694	FLORENCE, SC 29505
007-050-741	KEENE MARGARET A	9435 E STREET OF DREAMS	CROMWELL, IN 46732
007-050-734	KOHER MICHAEL M & JACQUELINE A	9458 E PARK LN E	CROMWELL, IN 46732
007-050-740	ROBERTS WILLIAM F JR & SHIRLEY J C/O NAT	P O BOX 1820	DAYTON, OH 45401
007-050-739	ROBERTS WILLIAM F JR & SHIRLEY J	11585 ENCHANTED FOREST LANE	CROMWELL, IN 46732
007-050-735	KOHER MICHAEL M & JACQUELINE A	9458 E PARK LN E	CROMWELL, IN 46732
007-050-738	SAYLOR STEVEN A & JACKIE L BARKER JTWFRS	P O BOX 21	NEW PARIS, IN 46553
007-050-736	SAYLOR STEVEN A & JACKIE L	PO BOX 21	NEW PARIS, IN 46553
007-050-737	SAYLOR STEVEN A & JACKIE L BARKER JTWFRS	P O BOX 21	NEW PARIS, IN 46553
007-050-690	WADAS EMILY C MRS	63 GLENDALE PH APT 1A	HAMMOND, IN 46320

KEY	OWNER_NAME	OWNER_ADD1	OWNER_ADD2
007-050-880	YODER STEPHEN A TRUST STEPHEN A YODER TR	20480 CR 50	NEW PARIS, IN 46553
007-050-881	LEHNER FRANK & JOSEPHINE	2673 SCOTT ST	PORTAGE, IN 46368
007-050-689	MUELLER JOHN W & DEBORAH L	352 N CHAUNCEY ST	COLUMBIA CITY, IN 46725
007-050-882	MACKO JOHN R & ELEANOR A	8006 MONALDI DR	MUNSTER, IN 46321
007-050-883	HIRE SUSAN G C/O RANDELL PEYTON	9314 E DOSWELL BLVD 0591	CROMWELL, IN 46732
007-050-884	HIRE SUSAN G C/O RANDELL PEYTON	9314 E DOSWELL BLVD 0591	CROMWELL, IN 46732
007-050-885	PEYTON RANDELL & JUDY TBE	P O BOX 164 0794	CROMWELL, IN 46732
007-050-886	PEYTON RANDELL & JUDY P	P O BOX 164 0992	CROMWELL, IN 46732
007-050-887	PEYTON RANDELL	P O BOX 164	CROMWELL, IN 46732
007-050-888	FREY KEN	64967 ORCHARD DR	GOSHEN, IN 46526
007-050-889	BLUNK JOHN E & DEBRA L	9421 SLEEPY HOLLOW	CROMWELL, IN 46732
007-050-890	BLUNK JOHN E & DEBRA L	9239 E CINDERELLA DR	CROMWELL, IN 46732
007-050-891	STAIGER DIANA	1230 HOPE ST	STAMFORD, CT 06907
007-050-688	MUELLER JOHN W & DEBORAH L	352 N CHAUNCEY ST	COLUMBIA CITY, IN 46725
007-050-892	KUHN PATRICK	9189 E CINDERELLA	CROMWELL, IN 46732
007-050-893	PESARCHIK MICHAEL A	11811 N PIED PIPER PKWY	CROMWELL, IN 46732-9695
007-050-894	MOSER ERIC W	405 W 3RD ST	LIGONIER, IN 46767
007-050-895	LOCHBIHLER VINCENT M & JUDY L	3505 NAGVAGA DR 0593	FT WAYNE, IN 46815
007-050-896	LINE ROBERT J & JOY %INLAND MORTGAGE COR	P O BOX 7189	INDIANAPOLIS, IN 46207-7189
007-050-897	LINE ROBERT J & JOY %INLAND MORTGAGE COR	P O BOX 7189	INDIANAPOLIS, IN 46207-7189
007-050-898	GREGOROWICZ BEN L & ALICE H	9174 E CINDERELLA DR	CROMWELL, IN 46732
007-050-899	GREGOROWICZ BEN L & ALICE H TBE	9174 E CINDERELLA DR	CROMWELL, IN 46732
007-050-924	SHIPLEY RICHARD F SR & MABRINE DELORIS	9239 LILAC	CROMWELL, IN 46732
007-050-923	SHIPLEY RICHARD F SR & MABINE D	9239 LILAC LN	CROMWELL, IN 46732
007-050-925	DODDS HORTON C & LOIS E	11695 N MC CULLOCH G91	SYRACUSE, IN 46567
007-050-900	DE HART SCOTT D & JOAN	1893 N WOODWAY	CROMWELL, IN 46732
007-050-922	S A M ENTERPRISE OF SOUTH BEND INC	PO BOX 586	ST JOSEPH, MI 49085
007-050-926	COMPTON THOMAS F OR DOROTHY J	547 RIVER AVE	SOUTH BEND, IN 46618
007-050-901	SCHRUMPF LEONA	13386 N EASTSHORE DR G91	SYRACUSE, IN 46567
007-050-902	ZIMMERMANN SHAWN C & KELLI J	1914 ALMOND DR	ELKHART, IN 46514-9016
007-050-921	SIDWELL STEPHEN J & KIMBERLY N BADOREK J	9199 E LILAC	CROMWELL, IN 46732
007-050-903	S A M ENTERPRISE OF SOUTH BEND INC	PO BOX 586	ST JOSEPH, MI 49085
007-050-904	JOHNSON JEFFREY L & SHARON L	9252 E CINDERELLA DR	CROMWELL, IN 46732
007-050-905	DUNCAN RANDY E & BONNIE J	9266 E CINDERELLA DR	CROMWELL, IN 46732
007-050-906	WELLS LARRY A	3445 E AMHURST LN	WARSAW, IN 46580

KEY	OWNER_NAME	OWNER_ADD1	OWNER_ADD2
007-050-907	RUSH JESS	9721 EAST SNOW WHITE LN	CROMWELL, IN 46732
007-050-908	S A M ENTERPRISE OF SOUTH BEND INC	PO BOX 586	ST JOSEPH, MI 49085
007-050-938	AMOS FRANK L & MICHELE	901 NORTHWOOD DR	ANDERSON, IN 46011
007-050-911	CRAMER BETHELENE SQUIBB LISA	52985 GLENMORE	ELKHART, IN 46514
007-051-254	JENSEN HERMAN W & BETTY E	1815 MAPLE LANE	GARRETT, IN 46738
007-051-256	SCHUSTER RAYMOND R & HELEN MARIE TBE	11418 N FASCINATION WAY 0391	SYRACUSE, IN 46567
007-051-238	BAKER BRENT	11387 N GOLDILOCKS LN 0591	CROMWELL, IN 46732
007-051-045	JOHNSON STEVEN B & BRIDGET K	11397 N MEMORIAL PKWY	CROMWELL, IN 46732
007-051-046	DETTMER DON V & VIRGINIA D	108 E FOURTH ST	AUBURN, IN 46706
007-051-235	S A M ENTERPRISE OF SOUTH BEND INC	PO BOX 586	ST JOSEPH, MI 49085
007-051-233	MACKO JOHN R & ELEANOR A	8006 MONALDI DR	MUNSTER, IN 46321
007-051-048	STRAND MICHAEL H	11369 N MEMORIAL PKWY	CROMWELL, IN 46732
007-051-135	DOSWELL LUCY C TRUST LUCY C DOSWELL TRUS	1513 HUFFMAN BLVD	FT WAYNE, IN 46808
007-051-049	MICKLESON SARA J	21340 KERN ROAD	SOUTH BEND, IN 46614-9756
007-051-134	DOSWELL LUCY C TRUST LUCY C DOSWELL TRUS	1513 HUFFMAN BLVD	FT WAYNE, IN 46808
007-051-133	SELLERS ROY J & FAY R	209 BISCAYNE BLVD	CROMWELL, IN 46732
007-051-077	BIEGHLER CYNTHIA ANN	11341 N MEMORIAL PKWY A92	CROMWELL, IN 46732
007-051-131	S A M ENTERPRISE OF SOUTH BEND INC	PO BOX 586	ST JOSEPH, MI 49085
007-051-130	LEMBERG RICHARD I & CATHY A	9337 E NATTI CROW RD	SYRACUSE, IN 46567
007-051-078	DETTMER VIRGINIA D	108 E 4TH ST	AUBURN, IN 46706
007-051-129	S A M ENTERPRISE OF SOUTH BEND INC	PO BOX 586	ST JOSEPH, MI 49085
007-051-127	REED THOMAS R II & PAMELA K	9349 E DOSWELL BLVD	CROMWELL, IN 46732
007-051-096	LANDIS G MASON JR & DONNA JEAN	1317 W 55TH ST	MARION, IN 46952
007-051-126	REED THOMAS R II & PAMELA K	9349 E DOSWELL BLVD	CROMWELL, IN 46732
007-051-125	REED THOMAS R II & PAMELA K	9349 E DOSWELL BLVD	CROMWELL, IN 46732
007-051-124	PERISHO PERRY W & JULIA A TBE	9219 E DOSWELL BLVD	CROMWELL, IN 46732
007-051-097	S A M ENTERPRISE OF SOUTH BEND INC	PO BOX 586	ST JOSEPH, MI 49085
007-051-123	FIELDS TRINA	306 N EAST ST	MILFORD, IN 46542
007-051-098	S A M ENTERPRISE OF SOUTHE BEND INC	PO BOX 586	ST JOSEPH, MI 49085
007-051-122	WYGANT JOHN R REVOCABLE TRUST C/O JOHN R	PO BOX 217	SYRACUSE, IN 46567
007-051-099	HOOVER DARLE C JR	6735 LAKEWORTH DR	INDIANAPOLIS, IN 46220-4033
007-051-121	DEWITT JULIE W	8121 E ROSELLA ST	SYRACUSE, IN 46567
007-051-100	MCKEE FRED B & SHELLY J	9481 E DOSWELL BLVD 0593	CROMWELL, IN 46732
007-051-120	COLUMBIA REALTY CORP TO-ENCHANTE HILLS C	P O BOX 52	NO MANCHESTER, IN 46962
007-051-101	TEAGUE JOHN H & LINDA	GENERAL DELIVERY	WOODBINE, KY 40771-9999

KEY	OWNER_NAME	OWNER_ADD1	OWNER_ADD2
007-051-119	WHEAT ROY J & JUDITH A	11199 N HUMPTY DUMPTY DR 0692	CROMWELL, IN 46732
007-051-102	COLUMBIA REALTY CORP	P O BOX 52	NORTH MANCHESTER, IN 46962
007-051-118	WHEAT ROY J & JUDITH A	11199 N HUMPTY DUMPTY DR 0692	CROMWELL, IN 46732
007-051-103	HODGES TIMOTHY A & HEATHER	2133 INNER CIRCLE PKWY	MUNSTER, IN 46321
007-051-117	MEYER JAMES E & LESLY K	11207 N HUMPTY DUMPTY DR	CROMWELL, IN 46732
007-051-104	MCNARY ROBERT C & SANDRA L	11153 N E WAWASEE DR	SYRACUSE, IN 46567
007-051-116	MEYER JAMES E & LESLY	11207 HUMPTY DUMPTY	CROMWELL, IN 46732-9639
007-051-105	MCNARY ROBERT C & SANDRA L	11153 N EAST WAWASEE DR G91	SYRACUSE, IN 46567
007-051-115	MEYER JAMES E & LESLY K	11207 N HUMPTY DUMPTY DR	CROMWELL, IN 46732
007-051-106	NELSON MILBURN & MARY BETH FONTANELLA JT	8780 WICKER AVE	ST JOHN, IN 46373
007-051-114	HOPP CHARLES M & DARLENE S	1210 SOUTH RIDGE ST	CROWN POINT, IN 46307
007-051-107	NELSON MILBURN & MARY BETH FONTANELLA	8780 WICKER AVE	ST JOHN, IN 46373
007-051-113	CUYLER G VINCENT & BARBARA J 3/4 KATHRYN	209 PINE TREE LANE 0592	LAGRANGE PK, IL 60526
007-051-108	ENCHANTED HILLS COMMUNITY ASSOC INC	PO BOX 547	CROMWELL, IN 46732
007-051-112	ALLAN DAWN 1/2 & BRIAN 1/2	11206 N HUMPTY DUMPTY DR	CROMWELL, IN 46732
007-051-109	COLUMBIA REALTY CORP	P O BOX 52	NORTH MANCHESTER, IN 46962
007-051-111	MICHAEL LARRY C & CAROLYN M %PRECEDENT M	9525 DELEGATES ROW #100	INDIANAPOLIS, IN 46240
007-051-110	COLUMBIA REALTY CORP	P O BOX 52	NORTH MANCHESTER, IN 46962
007-051-449	MICHAEL LARRY C & CAROLYN M %PRECEDENT M	9525 DELEGATES ROW #100	INDIANAPOLIS, IN 46240
007-051-450	S A M ENTERPRISE OF SOUTH BEND INC	P O BOX 586	ST JOSEPH, MI 49085
007-051-451	SHIPLEY RICHARD F & MABRINE	9239 LILAC LN	CROMWELL, IN 46732
007-051-452	S A M ENTERPRISE OF SOUTH BEND INC	PO BOX 586	ST JOSEPH, MI 49085
007-051-453	ALLAN BRIAN & DAWN E	11206 N HUMPTY DUMPTY	CROMWELL, IN 46732
007-051-454	FEDERAL HOME LOAN MORTGAGE CO	P O BOX 723788	ATLANTA, GA 30339
007-051-548	BRUNER ELIZABETH ELLEN	P O BOX 1913	WARSAW, IN 46580
007-051-547	THOMPSON MARSHA	9431 E DOSWELL BLVD 0593	CROMWELL, IN 46732
007-051-546	THOMPSON MARSHA	9431 E DOSWELL BLVD 0593	CROMWELL, IN 46732
007-051-455	FEDERAL HOME LOAN MORTGAGE CO	P O BOX 723788	ATLANTA, GA 30339
007-051-545	THOMPSON MARSHA M	9431 E DOSWELL BLVD 0593	CROMWELL, IN 46732
007-051-456	HACKER PAUL B & KAREN S	8312 E HATCHERY RD	SYRACUSE, IN 46567
007-051-544	S A M ENTERPRISE OF SOUTH BEND INC	PO BOX 586	ST JOSEPH, MI 49085
007-051-457	ALFORD JAMES D & DEBORAH	2706 ROCKHILL LANE	YODER, IN 46798
007-051-543	MCKEE FRED B & SHELLY J	9481 E DOSWELL BLVD 0593	CROMWELL, IN 46732
007-051-458	TATMAN DON E & SANDRA MAE	11042 N WAWASEE CIRCLE W 1190	CROMWELL, IN 46732
007-051-542	CLARK JEREMY & CARRIE A	11228 HONEYCOMB LANE N	CROMWELL, IN 46732

KEY	OWNER_NAME	OWNER_ADD1	OWNER_ADD2
007-051-459	WHEATLEY EMMETT L & EVELYN	447 EAGLE CREST DR 0591	BROWNSBURG, IN 46112
007-051-541	BAASE HAROLD B & GAYLE L	9371 E WAWASEE CIRCLE S	CROMWELL, IN 46732-9998
007-051-460	GIRNUS IDA A	1000 CEDAR RIDGE LN APT 305	RICHTON, IL 60471
007-051-540	ADAMAITIS GEORGE J & SHIRLEY M	10341 PALMBROOK TER	BRADENTON, FL 34207
007-051-461	HATSERAS MIKE & VAITSA	1440 WISCONSIN	BERWYN, IL 60402
007-051-539	TURNER LLOYD D & PHYLLIS J	8025 E 1290 N	SYRACUSE, IN 46567
007-051-462	SCHROCK ELI RAY	11601 CR 116	MIDDLEBURY, IN 46540
007-051-538	CLARK JEREMY & CARRIE A	11228 HONEYCOMB LANE N	CROMWELL, IN 46732
007-051-463	VIGLIOTTI JERRY D & SHIRLEY J	187 W CRAIG DR	CHICAGO HEIGHTS, IL 60411
007-051-537	SANDERS FRANK B & MARILYN R	4506 RIDGEWAY RD	RINGWOOD, IL 60072
007-051-464	CAPPS KEVIN & RENEE	11131 N WAWASEE CIRCLE W 0491	CROMWELL, IN 46732
007-051-536	LEININGER MARLENE	14445 SR 15 S LOT 4	DEFIANCE, OH 43512
007-051-465	BARR JOHN J JR & RHONDA L	11180 WAWASEE CIRCLE	CROMWELL, IN 46732
007-051-535	S A M ENTERPRISE OF SOUTH BEND INC	PO BOX 586	ST JOSEPH, MI 49085
007-051-466	WALLACE BRUCE H & CYNTHIA	10029 HIDDEN MEADOWS PLACE	FT WAYNE, IN 46825
007-051-534	HAGEN NANCY B & RICHARD D STAGE JTWROS	8143 E CHEROKEE	SYRACUSE, IN 46567
007-051-467	COPELAND DONALD J & MARILYN D TO COPELAN	1343 CUMBERLAND C W	ELK GROVE, IL 60007
007-051-533	HILBRICK EARL SR & PATSY L TBE	11218 HONEYCOMB LN 0593	CROMWELL, IN 46732
007-051-468	COPELAND WALLACE J JR & GERALDINE	12419 S MANSFIELD	ALSIP, IL 60803
007-051-532	BORNMAN CHRISTOPHER STEPHEN & NIMIA ELCI	11050 N WAWASEE CR	CROMWELL, IN 46732
007-051-469	MULVANEY BERNARD P & LINDA M	7001 W 127TH ST	PALOS HEIGHTS, IL 60463
007-051-531	SCOTT MICHAEL B & DANIELLE D	11016 DOLL DR	CROMWELL, IN 46732
007-051-470	TATMAN DON E & SANDRA M	11042 N WAWASEE CIRCLE W 1190	CROMWELL, IN 46732
007-051-530	SCOTT MICHAEL B & DANIELLE D	11016 DOLL DR	CROMWELL, IN 46732
007-051-471	YOUNG ROBERT W SR & DELORES M	2592 RD 331 S	BREMEN, IN 46506
007-051-529	HILBRICK EARL SR & PATSY L	11218 HONEYCOMB	CROMWELL, IN 46732
007-051-472	GULASSA ANTHONY C & CHARLENE HANLON	1330 LAKE AVE	WHITING, IN 46394
007-051-528	HILBRICK EARL SR & PATSY L	11218 HONEYCOMB	CROMWELL, IN 46732
007-051-473	DURR ROBERT L& MARIAN L	9381 E PROMONTORY PT DR	SYRACUSE, IN 46567
007-051-527	COLUMBIA REALTY CORP	P O BOX 52	NORTH MANCHESTER, IN 46962
007-051-474	COLE JAMES E & LISA K	11117 N POLYANNA PIKE	CROMWELL, IN 46732
007-051-526	PAYNE JOHN	725 WILLIAMS COVE DR	INDIANAPOLIS, IN 46260
007-051-475	STUMP TIMOTHY A & CAROLYN	11979 N E CIRCLE	CROMWELL, IN 46732
007-051-525	S A M ENTERPRISE OF SOUTH BEND INC	PO BOX 586	ST JOSEPH, MI 49085
007-051-476	BREWER LARRY A & G ANN	121 W NORTH CT	ELWOOD, IN 46036

KEY	OWNER_NAME	OWNER_ADD1	OWNER_ADD2
007-051-524	COLUMBIA REALTY CORP	P O BOX 52	NORTH MANCHESTER, IN 46962
007-051-477	AUER JOHN L & LAVERA	11152 HUMPTY DUMPTY DR	CROMWELL, IN 46732
007-051-523	S A M ENTERPRISE OF SOUTH BEND INC	PO BOX 586	ST JOSEPH, MI 49085
007-051-478	DURR ROBERT L & MARIAN L	9381 E PROMONTORY PT DR	SYRACUSE, IN 46567
007-051-522	GENETOS BASIL C & SHARON	1350 WESTOVER RD	FT WAYNE, IN 46807
007-051-479	COUCH BARBARA B QUALIFIED PERSONAL RESID	1609 FOREST PARK BLVD	FT WAYNE, IN 46805
007-051-521	COX KRISTOPHER L & STARR L	10090 W 900 N	CROMWELL, IN 46732
007-051-480	COPELAND WALLACE III TO MULHONEY BERNARD	7001 W 127TH ST	PALOS HEIGHTS, IL 60463
007-051-520	COX KRISTOPHER L & STARR L	10090 W 900 N	CROMWELL, IN 46732
007-051-481	STAHLY KEVEN L	11169 N WAWASEE CR 1291	CROMWELL, IN 46732
007-051-519	ARCHER GREG & ROBERT S JTROS	11075 N POLYANNA PIKE A92	CROMWELL, IN 46732
007-051-482	DEMENT JOEY J & JENNIFER J STANDARD FEDE	2600 W BIG BEAVER RD	TROY, MI 49084
007-051-518	COLUMBIA REALTY CORP	P O BOX 52	NORTH MANCHESTER, IN 46962
007-051-483	STOUDER RONALD E %ADVANTA MORTGAGE CORP	16875 W BERNARDO DR	SAN DIEGO, CA 92127
007-051-517	S A M ENTERPRISE OF SOUTH BEND INC	PO BOX 586	ST JOSEPH, MI 49085
007-051-484	SHIPLEY RICHARD F JR & VALERIE	11127 N HUMPTY DUMPTY DR A92	CROMWELL, IN 46732
007-051-516	ARCHER GREG & ROBERT S JTROS	11075 N POLYANNA PIKE 0593	CROMWELL, IN 46732
007-051-485	BUFF CONSTRUCTION INC	7971 E CHEROKEE RD	SYRACUSE, IN 46732
007-051-515	WARREN CHRISTOPHER A & RANDI L	11065 N POLYANNA PIKE	CROMWELL, IN 46732
007-051-486	DIXON STEVEN L & LEE A	11132 N HUMPTY DUMPTY DR A92	CROMWELL, IN 46732
007-051-514	STOUT THOMAS CONTRACT TO TIMOTHY K	11194 N HONEYCOMB LANE	CROMWELL, IN 46732
007-051-487	GALLMEIER DANNY B JR & SHADOW A FIRST NA	P O BOX 1447	WARSAW, IN 46580
007-051-513	BARTLETT ROBERT C	9419 WAWASEE CIRCLE S	CROMWELL, IN 46732
007-051-488	STAHLY KEVEN L	11169 N WAWASEE CIRCLE	CROMWELL, IN 46732
007-051-512	BARTLETT ROBERT C	9419 WAWASEE CIRCLE S	CROMWELL, IN 46732
007-051-402	HERMANN KRISTIN T & KELLEY C	11104 N POLYANNA PIKE	CROMWELL, IN 46732
007-051-511	HARTUNG CRAIG A	11062 POLLYANNA PIKE	CROMWELL, IN 46732
007-051-402	HERMANN KRISTIN T & KELLEY C	11104 N POLYANNA PIKE	CROMWELL, IN 46732
007-051-510	WARREN CHRISTOPHER & RANDI	0462 S CR 950 W	KIMMELL, IN 46760
007-051-491	LUCAS RICHARD DEAN & RHONDA JOANN % RICH	P O BOX 74	CROMWELL, IN 46732
007-051-509	WARREN CHRISTOPHER & RANDI	0462 S CR 950 W	KIMMELL, IN 46760
007-051-492	BUFF CONSTRUCTION INC	7971 E CHEROKEE RD	SYRACUSE, IN 46567
007-051-493	S A M ENTERPRISE OF SOUTH BEND INC	PO BOX 586	ST JOSEPH, MI 49085
007-051-508	KOSCIUSKO COUNTY HABITAT FOR HUMANITY IN	P O BOX 1913	WARSAW, IN 46581-1913
007-051-494	BUFF CONSTRUCTION INC	7971 E CHEROKEE RD	SYRACUSE, IN 46567

KEY	OWNER_NAME	OWNER_ADD1	OWNER_ADD2
007-051-495	GRZEGORZEWSKI EDWARD D & DONEALDA M	11074 N POLYANNA PIKE	CROMWELL, IN 46732
007-051-496	BULLOCK GEORGE A & ANN K & WILLIAM R & G	6965 E PUTTER PL	SYRACUSE, IN 46567
007-051-497	PULSONI TIMOTHY & DEBRA KAY	2733 ENGLE	PORTAGE, IN 46368
007-051-498	WILSON GLEN E	312 EDGEWATER AVE	SYRACUSE, IN 46567
007-051-499	HARTUNG CRAIG A	11062 POLLYANNA PIKE	CROMWELL, IN 46732
007-051-500	BUFF CONSTRUCTION INC	7971 E CHEROKEE RD	SYRACUSE, IN 46567
007-051-501	TEAGUE JOHN H & LINDA	GENERAL DELIVERY	WOODBINE, KY 40771-9999
007-051-502	DEWITT MICHAEL J	PO BOX 1553	WARSAW, IN 46581
007-051-503	TOPOREK TIMOTHY T TO HOMESTEAD MORTGAGE	26400 LAHSER RD #217	SOUTHFEILD, MI 48034
007-051-504	BOOHER ROBERT C & MARGARET E	11103 N WAWASEE CIRCLE E	CROMWELL, IN 46732
007-051-505	S A M ENTERPTISE OF SOUTH BEND INC	PO BOX 586	ST JOSEPH, MI 49085
007-051-506	HAGEN NANCY B & RICHARD D STAGE JTWROS	8143 E CHEROKEE	SYRACUSE, IN 46567
007-051-507	COLUMBIA REALTY CORP	P O BOX 52	NORTH MANCHESTER, IN 46962
007-056-091	PHILLIPS ROBERT ALLEN & NANETTE	404 W FIRST ST	MILFORD, IN 46542

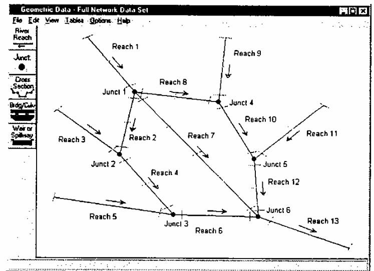
Appendix D: HEC-RAS Overview

HEC-RAS
River Analysis System

Use HEC-RAS for determining water surface elevations throughout a river network and analyzing bridges and culverts.

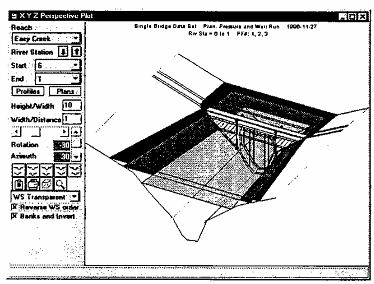
User Interface

- Lay out your river networks graphically.
- Review your cross-sections on-screen as you work.
- Enter data for bridges and culverts, and you can immediately view the graphical representation.
- Subdivide and combine existing reaches.



Hydraulics

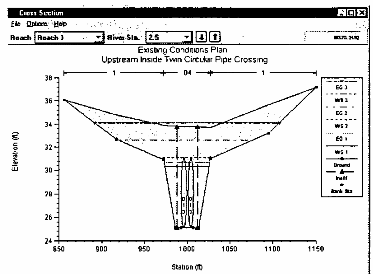
- Calculate water surface profiles based on steady, gradually varied flow for channel networks, dendritic systems, or a single river reach.
- Predict energy losses based on Manning's friction coefficients, and expansion and contraction losses.
- Evaluate floodway encroachments for floodplain management and insurance studies.
- Determine changes in water surface profile due to levees, bridges, and culverts. Handle rapidly varied flow conditions automatically, such as hydraulic jumps and bridge contractions.



- Modify a range of cross sections using the channel improvement options (and even obtain the cut and fill volumes).
- Include in-line weirs and gated spillways in the river system. Gate openings can even be adjusted differently for each profile.
- Compute bridge scour based on the routines outlined in HEC-18 (Hydraulic Engineering Circular 18, from the Federal Highway Administration).
- Follow the methods for low-flow computations laid out by the Federal Highway Administration using the WSPRO bridge routines.
- Analyze culverts under supercritical and mixed flow regimes, and even adverse slopes.

Output

- View the results three-dimensionally with X-Y-Z perspective plots. These show not only your cross-sections and structures, but also the water surfaces for several flood events.
- Use the built-in tables to create standard reports, including cross-section tables, bridge tables, culvert tables, etc.



- Include the graphical river system schematic, cross-sections, profiles, and more in your final report.

Source:
http://www.haestad.com

Appendix E: Agricultural Best Management Practices

APPENDIX E
AGRICULTURAL BEST MANAGEMENT PRACTICES (BMPS)

Best management practices, or BMPs, are restrictions, structures or practices that mitigate the adverse anthropogenic effects on runoff quality and/or quantity. Agricultural BMPs include various types of conservation buffers such as grassed waterways, no-till cropping, and many other structures and practices. The relative effectiveness of the BMP for reducing storm runoff peaks and volumes, and for addressing pollutants are generalized in the matrix below. Each BMP is subsequently described in more detail.

Table E-1

GENERAL EFFECTIVENESS OF SELECT AGRICULTURAL BMPS

BMP	Suspended Solids	Nitrogen	Phosphorus	Runoff Volume
Impoundments				
Dry Detention Ponds	•	•	•	•••
Wet Detention Ponds	•••	••	••	•••
WASCOBs				
Wetland Basins	•••	••	•••	•••
Wetland Channels	••	••	••	••
Vegetative Filters				
Filter Strips	••	•	•	•
Grassed Waterways	••	•	•	•
Farm Management Practices				
Residue Management	•••	••	••	••
Stripcropping	•••	••	••	••
Terracing	•••	••	•••	•••
Nutrient Management	••	•••	•••	••
Others				
Sand Filtration	•••	•	••	•

• = Usually not very effective treatment

••• = Usually very effective treatment

1. SAND FILTERS

Sand filters are a type of stormwater control structure used to treat runoff from buildings, roads, parking lots. Sand filters are also used to treat potable water, industrial process water and agricultural wastewater. Sand filters may be installed underground in trenches or pre-cast concrete boxes or above-ground in beds that can treat stormwater from drainage areas as much as five acres in size.

Sand filters are most common in urban areas and on sites with restricted space. The City of Austin, Texas and the State of Florida have built large, above-ground sand filters. Underground sand filters have been installed in several eastern states. Both versions pre-treatment to remove sediment, floating debris, and oil and grease to protect the filter. As stormwater flows through the filter bed, sediment particles and adsorbed pollutants are captured.

Pollutant removal for sand filters varies depending on the site, climate and loading. Overall removal for sediment and trace metals is better than removal of soluble pollutants. Table E-2 lists removal rates taken from the literature. Unfortunately, due to the large areas requiring treatment in agricultural crop watersheds, sand filters are generally not utilized.

Table E-2

SAND FILTER RELATIVE POLLUTANT REMOVAL EFFICIENCY
(Source: Schueler, *et al.* 1992)

Pollutant	Efficiency
Bacteria	Moderate
Oil and Grease	High
BOD	Moderate
Trace metals (sediment-bound)	Very High
Sediment	Very High
Total Phosphorus	Moderate
Total Nitrogen	Moderate

2. BUFFERS, FILTER STRIPS AND GRASSED WATERWAYS

Vegetation reduces the velocity of stormwater. This improves infltration and sedimentation, as well as prevents erosion. Vegetation is often part of a BMP system to remove particulates and slow runoff before it enters another treatment device. Buffer stips, filter strips and grassed waterways are described in this section.

The NRCS defines a filter strip as a strip or area of herbaceous vegetation situated between cropland, grazing land, or disturbed land (including forest land) and environmentally sensitive areas. NRCS defines a buffer strip similarly, as a strip or strips of perennial vegetation established in crop fields for wildlife habitat, erosion control, and water quality. Both of these BMPs generally apply in areas situated below cropland, grazing land, or disturbed land where sediment and/or contaminants may leave these areas and are entering environmentally sensitive areas. The NRCS' definition of a grassed waterway is a natural or constructed channel shaped or graded and established in suitable vegetation for the stable conveyance of runoff.

None of these BMPs are part of the adjacent cropland rotation. Overland flow entering filter strips or buffer strips shall be primarily sheet flow. Concentrated flow is dispersed by grading so that the flow is overland, as sheet flow.

Filter strips are typically areas of close-growing vegetation between pollutant sources and receiving waters. They can be used as outlet or pretreatment devices for other stormwater control practices. Filter strips can include shrubs or woody plants that help to stabilize herbaceous and grassy ground cover, or can be composed entirely of trees and other natural vegetation. Filter strips generally do not significantly reduce peak discharges or the volume of storm runoff, but they can be part of a comprehensive BMP system for meeting these needs.

According the NRCS standards, the filter strip should be located along the downslope edge of a field. The average watershed slope above the filter strip should be greater than 0.5% but less than 10%. The average annual sheet and rill erosion rate above the filter strip should be less than 10 tons per acre per year.

Strips should not be less than 20 feet, and protection of some resources may require much wider vegetation strips. Upgradient land slopes greater than 6% should have wider strips, possibly as wide as 130 feet. Floodplain buffer strips having higher flows and longer duration flooding may need to be upwards of 200-feet wide.

Although studies indicate highly varying pollutant removal, trees in strips can be more effective than grass strips alone because of the trees' greater uptake and long-term retention of plant nutrients. Properly constructed forested and grassed filter strips can be expected to remove more than 60 percent of the particulates and perhaps as much as 40 percent of the plant nutrients in urban runoff. Filter strips function best when they are level in the direction of stormwater flow toward the stream. This orientation makes for the finest sheetflow through the strip, increasing infiltration and filtering of sediment and other solids. Filter strips fail if maintenance is irregular.

Grassed swales are waterways vegetated with a dense growth of a hardy grass such as tall fescue or reed canary grass. A grassed waterway/vegetated filter system is a natural or constructed vegetated channel that is shaped and graded to carry surface water at a nonerosive velocity to a stable outlet that spreads the flow of water before it enters a vegetated filter. Grassed waterways and swales are common in agricultural and urban settings.

Minimum capacity for design of grassed waterways is generally intended to confine the peak runoff from a 24-hour, 10-year storm. Waterways may provide some reduction in stormwater pollution through infiltration of runoff water into the soil, filtering of sediment or other solid particles, and slowing the velocity and peak flow rates of runoff. These processes can be enhanced by adding small (4-10 inches high) dams across the swale bottom, thereby increasing detention time.

Pollutants are removed from surface flow by the filtering action of the grass, sediment deposition, and/or infiltration into the soil. The pollutant-removing effectiveness of swales is moderate to negligible depending on many factors, including the quantity of flow, the slope of the swale, the density and height of the grass cover, and the permeability of the underlying soil. Pollutant removal ranges from 30 to 90 percent for sediment and 0 to 40 percent for total phosphorus loads (Table E-3).

Table E-3

VEGETATIVE PRACTICES POLLUTANT REMOVAL EFFICIENCY
(Source: Schueler, 1987, Schueler *et al.* 1992)

Pollutant	Efficiency
Bacteria	Low
Oil and Grease	Moderate
BOD	Low
Trace metals	Moderate
Sediment	Moderate
Total Phosphorus	Low
Total Nitrogen	Low

To be effective, vegetative practices require flat areas that are large in relation to the drainage area, and deep water tables. Swales should have as little slope as possible to maximize infiltration and reduce velocities. Filter strips should not be used where slopes exceed 15 percent, and best performance occurs where the slope is 5% or less. Taller grass will slow velocities more but grass cut to a short length may take up more plant nutrients.

3. CONSTRUCTED WETLANDS

Over the last two decades, interest has increased for the use of natural physical, biological, and chemical aquatic processes for the treatment of polluted waters. Aquatic treatment systems have been divided into natural wetlands, constructed wetlands, and aquatic plant systems (USEPA, 1988). Of the three types, constructed wetlands have received the greatest attention for treatment of nonpoint source pollution. Constructed wetlands are a subset of created wetlands designed and developed specifically for water treatment (Fields, 1993). Constructed wetlands may be developed strictly for mitigation of adverse effects from development on natural wetlands. But, in this context, constructed wetlands serve in a similar capacity as other water quality BMPs, that is, to minimize pollution prior to its entry into streams, lakes and other receiving waters.

Among the most important treatment processes are the purely physical processes of sedimentation, induced by reduced velocities in the wetland. Sedimentation accounts for the relatively high removal rates for suspended solids, the particulate fraction of organic matter and sediment-bound nutrients and metals. Oils and greases are effectively removed through impoundment, photodegradation, and microbial action. Similarly, pathogens show good removal rates in constructed wetlands via sedimentation, natural die-off, and UV degradation. Dissolved constituents such as soluble organic matter, ammonia and ortho-phosphorus tend to have lower removal rates. Soluble organic matter is largely degraded aerobically by bacteria and periphyton. Ammonia is removed through microbial nitrification-denitrification, plant uptake, and volatilization. Nitrate is removed through denitrification and plant uptake. Denitrification is the primary removal mechanism. The microbial degradation processes are relatively slow, particularly the anaerobic denitrification steps, and require longer residence times, a factor which contributes to the variable performance of constructed wetlands systems for dissolved nitrogen. Phosphorus is removed mainly through soil sorption, plant assimilation and burial, processes which are slow and varied. Consequently, phosphorus removal rates are variable and typically trail behind those of nitrogen.

Constructed wetlands can achieve or exceed the pollutant removal rates as estimated for wet pond detention basins and dry detention ponds. General ranges of removal for various pollutants are given below.

Table E-4

CONSTRUCTED WETLAND POLLUTANT REMOVAL EFFICIENCY
(Source: Schueler, 1987, Schueler *et al.* 1992)

Pollutant	Efficiency
Bacteria	High
Oil and Grease	Very high
BOD	Moderate
Trace metals (sediment-bound)	High
Sediment	High
Total Phosphorus	High
Total Nitrogen	Moderate

The use of constructed wetlands for stormwater treatment remains an emerging technology and design criteria continue to evolve. General design considerations include the requirement to reduce stormwater inflow velocities and provide opportunity for initial sedimentation. It is important to maximize the hydraulic residence time and the distribution of flow over the treatment area, and to avoid hydraulic short-circuiting. Emergent macrophytes provide substrate for periphyton and are a storage vector for carbon and nutrients. Generally, native emergent vegetation is designed for. Plants must be chosen to withstand the pollutant loading and the frequent fluctuation in water depth.

Constructed wetlands can be a very effective part of a BMP system. Associated features should incorporate minimization of initial runoff volumes; routing of runoff using grassed waterways, swale checks, and other measures; pre-treatment of collected runoff to minimize sediment and associated pollutant loads; and, off-line attenuation of larger storm event runoff to optimize wetland performance and minimize downstream erosion-related water quality impacts.

4. NATURAL AND RESTORED WETLANDS

Natural wetlands also improve water quality. Protection or restoration of wetlands to maintain or enhance water quality is acceptable. However, nonpoint source pollutants should not be intentionally diverted to wetlands for primary treatment. Wetlands should be part of an integrated landscape approach to nonpoint source control, and tied to BMPs in upgradient source areas.

5. WET RETENTION PONDS

Wet retention ponds or basins temporarily detain stormwater. The permanent pool of water enhances the removal of many pollutants. These ponds fill with stormwater and release it slowly. Pollutant removal mechanisms in wet ponds include: sedimentation; biological uptake by plants, algae and bacteria; and, decomposition. Wet ponds have some capacity to remove dissolved nutrients, an important characteristic to protect lakes from eutrophication. Because of the permanent pool, wet ponds can remove moderate to high amounts of most pollutants and are more effective in removing nutrients than most other BMPs.

Table E-5

WET DETENTION POND
POLLUTANT REMOVAL EFFICIENCY
(Source: WEF & ASCE, 1998)

Pollutant	Wet Retention Pond	Extended Detention Pond
BOD	20 – 40%	20 – 40%
Zinc	40 – 50%	40 – 50%
Lead	70 – 80%	70 – 80%
Sediment	70 – 80%	70 – 80%
Dissolved Phosphorus	50 – 70%	0
Total Phosphorus	50 – 60%	20 – 50%
Dissolved Nitrogen	50 – 70%	0
Total Nitrogen	30 – 40%	20 – 30%

6. WATER AND SEDIMENT CONTROL BASIN (WASCOB)

Water and sediment control basins, or WASCOBs, are earth embankments or combinations of ridges and channels, generally constructed across the slope and minor watercourses to form a sediment trap and a water detention basin. WASCOBs are a popular BMP, and hundreds have been constructed in Indiana alone. These structures improve the ability to farm sloping land, reduce watercourse and gully erosion, trap sediment, reduce and manage onsite and downstream runoff, and improve downstream water quality.

This practice applies to sites where:

1. The topography is generally irregular,
2. Waterway and/or gully erosion is a problem,
3. Sheet and rill erosion is controlled by other conservation practices,
4. Runoff and sediment has damaged land and improvements,
5. Soil and site conditions are suitable, and,
6. Adequate outlets are available or can be provided.

This practice is not applicable to waterways where construction of the basin would destroy important woody wildlife cover and the present watercourse is capable of handling the concentrated runoff without serious erosion.

Water and sediment control basins are consistent with terrace intervals (see Table E-9). The drainage of each basin is designed to limit the duration of ponding, infiltration, or seepage so that the structure does not damage nearby crops. Where land ownership or physical conditions preclude treatment of the upper portion of a slope with terraces, a water and sediment control basin may be used to separate this area from, and permit treatment to the lower part of the slope. The uncontrolled drainage area to the basin used for this purpose should not exceed 30 acres.

The basins should be large enough to control the runoff from a 10-year, 24-hour-frequency storm without overtopping. The capacity of basins designed to provide flood protection or to function with other structures may be larger. Another storage volume design consideration is the anticipated accumulation of sediment, which could be estimated with the Universal Soil Loss Equation (USLE).

WASCOBs should be part of an overall system to protect soil and water resources. Practices such as terracing, contouring, conservation cropping, conservation tillage, and crop residue management should also be used to control erosion.

Water and sediment control basins shall not be used in place of terraces. When a ridge and channel extend beyond the detention basin or level embankment, terraces are appropriate.

This BMP may reduce the volume and rate of discharge. When underground outlets are used, infiltration through the catchment will increase and runoff will be decreased. Peak flows will be reduced by temporary storage. Where snow is present, it is trapped in the channels and catchments of the BMP and infiltrates into the soil. This BMP traps and removes sediment-attached pollutants from runoff. Trap efficiencies for sediment and total phosphorus may exceed 90 percent in Indiana's silt loam soils. Dissolved substances, such as nitrates, may also be removed from discharge from downstream areas with increased infiltration.

7. RESIDUE MANAGEMENT

There are several agricultural BMPs that increase the plant residue in soils and reduce erosion. Among these are no-till/strip till, mulch till, ridge till, and seasonal residue management. Each of these BMPs is instrumental in conserving soil moisture, increasing soil infiltration, reducing soil loss, and improving soil tilth.

The NRCS defines no-till/strip till as managing the amount, orientation and distribution of crop and other plant residues on the soil surface year round, while growing crops in narrow slots, or tilled or residue free strips in soil previously untilled by full-width inversion implements. This practice applies to all cropland and other land where crops are grown. Combines or similar machines used for harvesting are equipped with spreaders that distribute plant residue over the fields so that residues are retained on the field. Post-harvest grazing should not be allowed. Planters are equipped to plant directly through untilled residue or in a tilled seedbed prepared in a narrow strip along each row. Although not universal, no-till planting generally relies on an increased use of herbicides to control weeks, but greatly reduces soil loss from the fields. No till or strip till can be practiced continuously or may be part of a system which includes other tillage and planting methods such as mulch till.

The mulch till practice is similar, and defined by NRCS as managing the amount of crop and other plant residues on the soil surface year round while growing crops where the field surface is tilled prior to planting. This BMP applies to all crop land and applies to tillage for both annual and perennial crops. Tillage implements are equipped to operate through plant residues without clogging and to maintain residue on or near the soil surface by undercutting or mixing. Planters, drills, or air seeders plant in residue on the soil surface or mixed in the tillage layer.

Ridge till is manages the amount of crop residues on the soil surface year-round, while growing crops on preformed ridges alternated with furrows protected by crop residue. Following harvest, residues are left until planting with no additional disturbance except for normal weathering. Ridge height is maintained throughout the harvest and winter seasons by controlling equipment or livestock traffic. After planting, residues are maintained in the furrows until the ridges are rebuilt by cultivation. Ridges are rebuilt to their original height and shape during the last row cultivation. Loose plant residues are retained on the field and uniformly distributed on the soil surface. Cultivation and planting equipment designed to operate on ridges is used, such as cultivators equipped with ridging attachments, and planters equipped with ridge planting attachments such as row cleaning devices and guidance systems. Planting and fertilizer placement shall disturb no more than one third of the row width. Soil and residue removed from the top of the ridge shall be moved into the furrow between the ridges. After planting, the top of the ridge is at least three inches higher than the furrow between the ridges.

Seasonal residue management involves using plant residues to protect cultivated fields during critical erosion periods. Wherever possible, the farmer should leave stubble standing over winter to prevent soil erosion and to trap snow. The management of crop residue is based on the amount of residue produced by the crop. When relatively small amounts of residues are available other practices will have to be used to maintain the necessary residue cover. This may include limiting grazing of the crop residues and not baling the cover.

8. STRIPCROPPING

Contour stripcropping is the growing of crops in a systematic arrangement of strips or bands on the hillside contour to reduce water erosion. The crops are arranged so that a filter strip of grass or close-growing crop is alternated with a strip of clean-tilled crop or fallow; or a strip of grass is alternated with a close-growing crop. Contour stripcropping is applicable to sloping cropland and on certain recreation and wildlife land where the topography is uniform enough to permit tilling and harvesting, and where it is an essential part of a cropping system to effectively reduce soil and water losses.

Contour strips should outlet into a stable outlet such as a waterway, water and sediment control basin, field border or other nonerosive areas and not outlet into end rows where excessive erosion down the slope might be accelerated. Contour strips are established with consideration given to the field and machinery conditions with up to 10 percent deviation of strip widths permissible (Table E-6).

Table E-6

CONTOUR STRIP WIDTHS
(Source: NRCS Conservation Standards)

Slope	P Values[1/]			Maximum Strip Width[2/]	Maximum Slope Length[3/]
(%)	A	B	C	(feet)	(feet)
1 to 2	0.30	0.45	0.60	130	800
3 to 5	0.25	0.38	0.50	100	600
6 to 8	0.25	0.38	0.50	100	400
9 to 12	0.30	0.45	0.60	80	240
13 to 16	0.35	0.52	0.70	80	160

1/ P Values:

A – For 4-year rotation of row crop, small grain with meadow seeding, and 2 years of meadow.

B – For 4-year rotation of 2 years row crop, winter small grain with meadow seeding, and 1-year meadow.

C – For alternate strips of row crop and winter small grain.

2/ Adjust strip width limit, generally downward, to accommodate widths of farm equipment.

3/ Maximum length may be increased by 10 percent if residue cover after crop planting will regularly exceed 50 percent.

Field stripcropping is similar to contour stripcropping. Field stripcropping is the growing of crops in a systematic arrangement of strips or bands across the general slope, not on the contour, to reduce water erosion. The crops are arranged so that a strip of grass or close-growing crop is alternated with a clean-tilled crop or fallow. It is applicable for controlling erosion and runoff on sloping cropland where contour stripcropping is not practical. Strips are laid out across the slope as nearly on the contour as practicable. No two adjoining strips will be in clean-tilled crops or fallow. As with contour stripcropping, grassed waterways, water and sediment control structures, terraces or diversions should be established and maintained where concentrated water flow would otherwise cause gully erosion. The widths of strips are defined below. A deviation of 20% in width is acceptable.

Table E-7

FIELD STRIPCROPPING STRIP WIDTHS
(Source: NRCS Conservation Standards)

Percent Slope	Strip Width (feet)
1 – 2	130
3 – 8	100
9 – 16	80

Both field and contour stripcropping affect the water budget, especially volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation and ground water recharge. These BMPs also have filtering effects on water quality because the strip vegetation and reduces movement of sediment and dissolved and sediment-attached substances.

9. TERRACING

A terrace is an earth embankment, channel, or a combination ridge and channel constructed across the slope to reduces slope length, erosion, and sediment content in runoff water. It is a broadly practiced BMP wherever water erosion is a problem, there is a need to conserve water, and the soils and topography are such that terraces can be reasonably constructed and farmed.

As with stripcropping, terrace spacing is usually determined by the Universal Soil Loss Equation (USLE). The spacing shall not exceed the slope length determined by using the allowable soil loss, the most intensive use planned, the expected level of management, and the terrace P factor (Table E-8).

Table E-8

TERRACE P FACTORS

(Source: NRCS Conservation Standards)

Horizontal Interval	Closed Outlets[1]	Open outlets, with percent grade [2]		
(feet)		0.1–0.3	>0.3-0.7	>0.7
<110	0.5	0.6	0.7	1.0
110 - <140	0.6	0.7	0.8	1.0
140 - <180	0.7	0.8	0.9	1.0
180 - <225	0.8	0.8	0.9	1.0
225 – 300	0.9	0.9	1.0	1.0
>300	1.0	1.0	1.0	1.0

NOTES:

If contouring or stripcropping P factors are appropriate, they can be multiplied by the terrace P factor for the composite P factor.

1/ "P" factor for closed outlet terraces also apply to terraces with underground outlets and to level terraces with open outlets.

2/ The channel grade is measured on the 300 ft of terrace or the one-third of total terrace length closest to the outlet, whichever is less.

The maximum horizontal interval between terraces should not exceed the distances tabulated below for the conditions shown.

Table E-9

MAXIMUM HORIZONTAL INTERVAL FOR TERRACES
(Source: NRCS Conservation Standards)

Slope	USLE – R Factors		With Contour Stripcropping
	35 to 175	>175	
(%)	(ft)	(ft)	(ft)
0 – 2	500	450	600
2.1 – 4	400	300	600
4.1 – 6	400	200	600
6.1 – 9	300	150	400
9.1 – 12	250	150	250
12.1 – 18	200	150	150
18.1 – up	200	150	150
Minimum spacing required, all slopes	150	90	90

The maximum limits should not be exceeded when making adjustments as indicated below. Spacing may be increased as much as 10% to provide better alignment or location, to adjust for farm machinery, or to reach a satisfactory outlet. Spacing may be increased an additional 10% for terraces with underground outlets. For level terraces used for erosion control and water conservation, the spacing is determined as indicated above, but the maximum horizontal spacing should never exceed 600 ft. Additionally the terrace shall have enough capacity to control the runoff from a 10-year frequency, 24-hour storm without overtopping. Other design criteria are available from the NRCS.

Terraces should be part of the treatment system to protect soil and water resources. In addition, practices such as contouring, a conservation cropping system, conservation tillage, and crop residue management shall also be used to control erosion. Terraces should not be used in place of water and sediment control basins. The planned management system should reduce soil loss in the terrace interval to prevent excess maintenance and operation problems.

Storage terraces retain runoff, increase infiltration, and conserve soil moisture. Gradient terraces may cause a slight increase to a significant decrease in surface runoff depending on field topography and terrace channel grade. This BMP reduces slope length and the amount of surface runoff which passes over the area downslope from the structure. The erosion rate and production of sediment within the terrace interval will be reduced. Terraces trap sediment and reduce the sediment and associated pollutant content in the runoff water.

Terraces intercept and conduct surface runoff at a nonerosive velocity to stable outlets, thereby reducing gully erosion. Trap efficiencies for sediment and total phosphorusmay exceed 90 percent for terraces with underground outlets in Indiana's silt loam soils. Underground outlets may collect soluble nutrient and pesticide leachates and convey them directly to surface waters. In this way, by collecting surface runoff and conveying it directly to a receiving stream, terraces may increase the delivery of pollutants to surface waters. Terraces may have a detrimental effect on water quality if they concentrate and accelerate delivery of dissolved or suspended nutrient or pesticide pollutants to surface or ground waters.

10. NUTRIENT MANAGEMENT

Proper nutrient management economizes the natural process of nutrient cycling to optimize crop growth and minimize environmental losses. According to NRCS (1999), the practice of nutrient management serves four major functions:

1. Supplies essential nutrients to plants for adequate production,
2. Provides for efficient and effective use of scarce nutrient resources,
3. Minimizes environmental degradation caused by excess nutrients in the environment, and,
4. Helps maintain or improve the physical, chemical, and biological condition of the soil.

Modern agricultural production depends on an adequate supply of nutrients being available to the crops. The agricultural yield increases during the last 50 years can be, in part, attributed to high levels of crop nutrition that support high yielding crop varieties. Unfortunately increased use of nutrients has, and continues to, damage the environment. Excess nutrients produce nuisance vegetation including algae, which diminish the economic, social and environmental benefits of aquatic and terrestrial habitats.

The objective of nutrient management is to supply adequate chemical elements to the soil and plants without creating an imbalance in the ecosystem. Protecting the environment requires controlling both the source of nutrients and their fate and transport from those sources. Nutrient management assessment tools available include tools to assess the agronomic needs of a crop and tools to assess environmental risk associated with nutrient applications. Agronomic needs assessment tools include:

- Traditional soil tests, providing an important baseline of information, should be performed every 3 to 5 years, or more often if conditions change.
- Plant tests provide information on the nutrient status of the crop, and can determine the success of the current nutrient management plan in meeting crop needs.
- Organic materials analysis, where manure or municipal sewage sludge are applied to fields, should include moisture content. These data are necessary to develop an accurate nutrient budget.

Environmental risk assessment tools provide information on the fate, transport and potential environmental risk associated with nutrient applications. These tools may identify sensitive areas where nutrient management is critical to protect a water resource. A few of the less complex risk assessment tools include:

- The leaching index (LI) assesses the intrinsic probability of leaching occurring if nutrients are present and available to leach. LI is a simple index of potential leaching based on average annual percolation and seasonal rainfall distribution.
- The Universal Soil Loss Equation (USLE) assesses the potential for soil and adsorbed nutrient loss through water erosion.
- The Water Quality Indicators Guide (WQIG) is a qualitative tool for assessing surface water quality impacts from five major sources of agriculturally related nonpoint source pollution: sediment, nutrients, animal waste, pesticides, and salts.
- The Nitrate Leaching and Economic Analysis Package (NLEAP) is a moderately complex, field scale model that assesses the potential for nitrate leaching under agricultural fields. NLEAP can be a powerful tool to assess nutrient management planning decisions.
- The phosphorus index (PI) is a simple assessment tool that examines the potential risk of P movement to streams and lakes based on various landforms and management practices.
- The 303(d) list can often be used to help assess the potential environmental risk associated with a particular land area. Indiana's 303(d) report is available at www. This report lists waterbodies designated as impaired for one or more of its designated uses.

- Water quality monitoring can be used to assess the potential impairment of waterbodies and associated environmental risk. Long-term monitoring, such as monitoring performed by the IDEM and U.S. Geological Survey can show quantitative trends in water quality over time.
- A variety of water quality models, including AGNPS, WATERSHED, ANAGNPS, SWRRB, and SWAT, may be used to look at the influence of different management scenarios and environmental conditions on the potential environmental risk of nutrient contamination to waterbodies.

A nutrient management plan is a farm's guide for making decisions on the placement, rate, timing, form, and method of nutrient application. They help producers become fully aware of the steps that need to be taken to successfully manage their nutrients and protect natural resources. Components of a nutrient management plan are listed in the adjacent text box. These elements are all-inclusive, but are guidelines for the minimum requirements for a nutrient management plan.

There are abundant references on nutrient conservation practices for pollution control and reduction. Many of the available techniques are related to soil erosion control. Nutrient control techniques generally fall into one or more of the following categories:

- Source reduction
- Reduction of nutrient availability
- Reduction of soil particle detachment
- Reduction of dissolved and suspended nutrient transport

Nutrient Management Plan Components

1. Aerial photographs or maps
2. Sensitive resource areas and nutrient restriction areas
3. Results of soil, plant and organic materials analyses
4. Crop sequence and rotation plan
5. Expected crop yields
6. Quantification of nutrient sources
7. Crop nutrient budget
8. Recommended rates, timing and methods of application
9. Operation and maintenance

REFERENCES

Fields, S. 1993. Regulations and Policies Relating to the Use of Wetlands for Nonpoint Source Pollution Control. Pages 151-158 in Created and Natural Wetlands for Controlling Nonpoint Source Pollution, R.K. Olson (ed.), CRC Press, Boca Raton, FL.

Natural Resources Conservation Service (NRCS). 1999. CORE4 Conservation Practices Training Guide. The Common Sense Approach to Natural Resource Conservation. USDA NRCS, August, 1999.

Schueler, T.R., 1987. Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs. Publication no. 87703. Metropolitan Washington Council of Governments. 275pp.

Schueler, T.R. P.A. Kumble, and M.A. Heraty. 1992. A Current Assessment of Urban Best Management Practices: Techniques for Reducing Non-Point Source Pollution In the Coastal Zone. Publication no. 92705. Metropolitan Washington Council of Governments. Washington, DC. 127pp.

US Environmental Protection Agency. 1988. Design Manual: Constructed Wetlands and Aquatic Plant Systems for Municipal Wastewater Treatment. EPA/625/1-88/022. U.S. Environmental Protection Agency, Office of Research and Development, Washington, DC. 83pp.

Water Environment Federation (WEF) and American Society of Civil Engineers (ASCE). 1998. Urban Runoff Quality Management. WEF, Alexandria, Virginia.

LAKE WAWASEE ENGINEERING FEASIBILITY STUDY

Identification of Potential Pollution Control Projects

This memorandum identifies watershed alternatives for improving water quality at Lake Wawasee, in Koscuisko County, Indiana. It documents Task 1 in the engineering feasibility study authorized by the Wawasee Area Conservancy Foundation (WACF) under their Lake and River Enhancement (LARE) grant.

After meeting with interested parties at the Lake Wawasee Engineering Feasibility Study Public Meeting #1 on August 30, 2000 and reviewing available historical data, the following improvement measures are reviewed herein, and recommendations are presented for full feasibility level evaluation.

Improvement 1:	Restoration of the original flow channel from the Enchanted Hills through Johnson Bay
Improvement 2:	Grade stabilization structures in Enchanted Hills subwatershed
Improvement 3:	Bank stabilization in Enchanted Hills subwatershed
Improvement 4:	Sediment trap and constructed wetland on Dillon Creek (Enchanted Hills)
Improvement 5:	Erosion control on development sites (e.g., Leeland Addition and South Shore)
Improvement 6:	Sediment traps and/or stormwater retention in the Leeland Addition (Martin Ditch) and South Shore subwatersheds
Improvement 7:	A reconstructed wetland in the Bayshore Swamp

Stormwater samples will be taken in the Bayshore, South Shore, and Dillon Creek Subwatersheds to gain further information on sediment and nutrients loadings at these locations. This data will be incorporated into the Engineering Feasibility Study as it becomes available.

Background Information

Background data on Lake Wawasee includes *Preliminary Investigation of the Lakes of Kosciusko County* (1989), *Enchanted Hills Watershed Evaluation* (1994), *Lake Enhancement Diagnostic/Feasibility Study for the Wawasee Area Watershed* (1995), and several letter reports focusing on specific areas around the lake. Located in Kosciusko County in northern Indiana, Lake Wawasee is Indiana's largest natural lake. The lake measures 3,400 acres and is a popular site for recreation and fishing. Runoff from the 23,918-acre watershed flows into Lake Wawasee through Turkey Creek, Papakeechie Lake, Bonar Lake, Dillon Creek/Enchanted Hills, and several smaller drainages. Lake Wawasee's watershed drains to the northwest to the St. Joseph River basin.

Lake Wawasee has historically exhibited high water quality, however during runoff events, plumes of sediment have been observed to enter the lake at several inlet areas. The 1995 Diagnostic/Feasibility report identified areas of the watershed in which improvements are necessary. These areas include the Enchanted Hills, South Shore, Bayshore, and Leeland Addition subwatersheds. The possible pollution control projects are detailed below.

Description of Improvements

Improvement 1: Restoration of the Original Flow Channel from the Enchanted Hills through Johnson Bay. When the Enchanted Hills subdivision was developed, Dillon Creek was diverted through the channels and into Lake Wawasee near Cedar Point. Previously, Dillon Creek flowed into Johnson Bay through the wetland system to the north and east of the bay. Possible water quality benefits of rerouting Dillon Creek through the Johnson Bay wetland include reduced sediment or nutrient load entering Lake Wawasee from the Dillon Creek/Enchanted Hills area due to slowing of the water in the wetland and plant uptake of nutrients, and greater flushing potential for the Enchanted Hills channels. Several options for this improvement include:

- Creating a stream channel connecting the northernmost channel in Enchanted Hills to the Johnson Bay wetland;
- Connecting the westernmost channel in Enchanted Hills to the Johnson Bay wetland via the original flowpath; and
- Diverting Dillon Creek around the Enchanted Hills channels to the Johnson Bay wetland.

Hydrologic investigations will be required to ensure that water levels in the lake and the channels would support a connection to the Johnson Bay wetland. In order for this alternative to be implemented, it will require permits from the U.S. Army Corp of Engineers and Indiana DNR Division of Water. Other concerns include easement availability, road and utility crossings, and topography. Possible negative effects include loss or modification of wetland habitat and disruption or destruction of natural hydrology and detention capabilities. We consider the potential adverse effects on the Johnson Bay wetland to be significant.

Johnson Bay Wetland Characterization

Harza reconnoitered vegetation communities in Johnson Bay. Dominant species are listed in Table 1. No endangered, threatened or rare species were found. Obligate wetland species, facultative wetland species, facultative upland species and upland species were found there, testifying to the variety of habitats and hydrologic regimes present. We characterize the Johnson Bay wetland as a freshwater marsh, with emergent aquatic plants growing in a permanent to seasonal shallow water. Scrub-shrub wetland communities exist both within and bordering the emergent community.

Table 1

JOHNSON BAY WETLANDS DOMINANT VEGETATION SPECIES

Common Name	**Latin Name**	**Wetland Indicator Category**
Broad-Leaved Arrowhead	*Sagittaria latifolia*	OBL aquatic - emergent
Pond Lilly	*Nuphar lutea*	OBL aquatic - emergent
Water Lilly	*Nymphaea odorata*	OBL aquatic - emergent
Water Shield	*Brasenia schreberi*	OBL aquatic - emergent
Narrow-Leaf Cattail	*Typha angustifolia*	OBL
Buckbean	*Menyanthes trifoliata*	OBL
Marsh Fern	*Thelypteris thelypteroides*	FACW+
Spotted Touch-Me-Not	*Impatiens capensis*	FACW
Nuttall's Waterhemp	*Amaranthus rudis*	FACW
Sensitive Fern	*Onoclea sensibilis*	FACW
Silver Maple	*Acer saccharinum*	FACW
Green Ash	*Fraxinus pennsylvanica*	FACW
Red-Osier Dogwood	*Cornus stolonifera*	FACW
River-Bank Grape	*Vitis riparia*	FACW-
Eastern Cottonwood	*Populus deltoides*	FAC+
Smooth Rose	*Rosa blanda*	FACU
Black Walnut	*Juglans nigra*	FACU

Key: OBL = obligate wetland species; probability of occurrence in wetlands: > 99%
FACW+ = facultative wetland species; probability of occurrence in wetlands: 51 to 66%
FACW- = facultative wetland species; probability of occurrence in wetlands: 34 to 50%
FACU+ = facultative upland species; probability of occurrence in wetlands: 17 to 33%
FACU- = facultative upland species; probability of occurrence in wetlands: 1 to 16%
UPL = upland species; probability of occurrence in wetlands: <1%

Recommendations

Table 2 outlines the benefits and disadvantages of each alternative for the restoration of the original flow channel from Enchanted Hills through Johnson Bay.